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ABSTRACT

Energy 80 is a booklet of energy topics for junior/high/middle school students. The topics are presented in 16 short sections (spreads). Topics include: energy forms; energy rules; solar energy; food energy; origin of fossil fuels; coal; oil and gas production and consumption; nuclear fission; renewable energy sources; history of United States energy; energy production and consumption (in flow chart format); investing in energy; buying energy abroad; saving energy at home; energy and happiness; and conservation in business and industry. Colorful drawings are provided to illustrate the energy topics and concepts discussed in each section. A list of questions to answer (suggesting that the questions be answered on a separate piece of paper) is included in the first page of the booklet. It is indicated in the teachers' guide designed for use with this booklet that although designed for junior high/middle schools students in science and social studies classes, the booklet was found suitable for use in upper grades and, to a lesser extent, in upper elementary grades. (JN)

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For the 1981-82 School Year

Energy80

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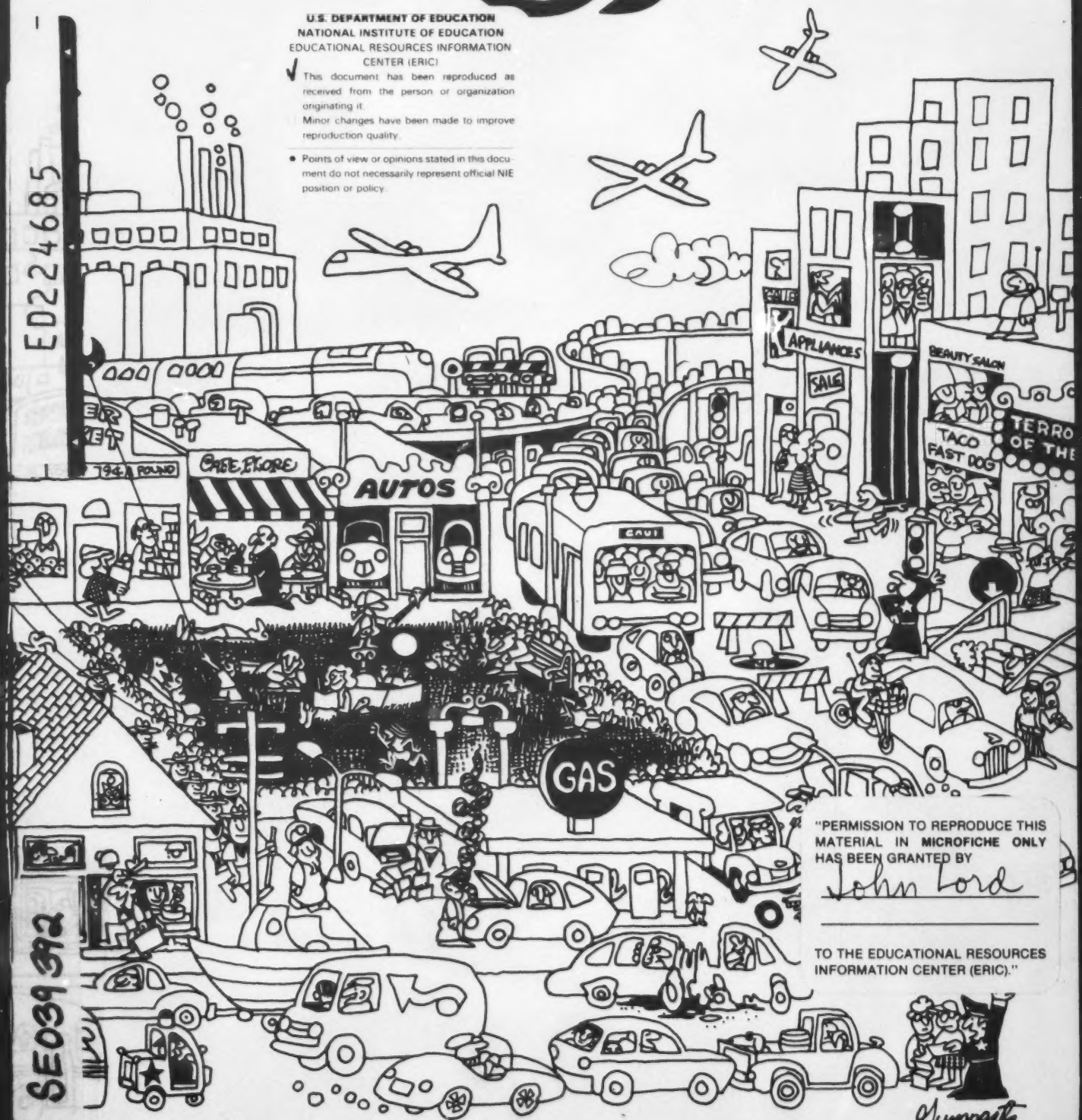

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Energy 80

Greetings to Texas students and teachers.

America today faces a greater threat to its future than at any time since World War II.

Energy is a major part of the problem. Our nation depends on oil imported from very unstable countries in the Middle East.

This dependence has caused an inflation rate that is higher than at any time in my memory; our dollar value is at its lowest in modern times; our national security is threatened; and America's future economic outlook is not encouraging.

The only solution is to produce energy here in this country. We must set free our oil and gas, coal, and nuclear industries, which are now restrained by many government regulations.

America's strength is based on the free enterprise system. We must let that system go to work, and turn loose our ability to research and develop alternate energy sources — such as solar power from the sun.

At the same time, we must practice energy conservation — such as riding in a carpool to save fuel.

We must support decontrol of oil and gas prices. This means a lifting of government controls over setting the price paid for oil and gas. Decontrol will bring prices of energy produced in America nearer the prices paid in other parts of the world.

Our producers should invest those higher profits directly back into production of more energy. This would increase energy production in America, leading to less dependence on importing foreign fuel, economic growth, and a stronger dollar.

Our America of the '80s must be better, stronger, and more prosperous than ever before. Young Texans have an important role now and in the future toward building a stronger state and nation. An understanding of the energy situation is essential to preparing them for this role.

W.P. Clements, Jr.
Governor from the State of Texas

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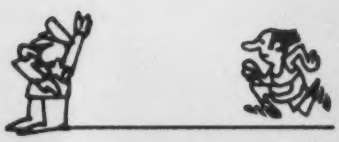


This Energy Book belongs to:

This booklet is yours to take home and keep. When you are at home, answer these questions. As you learn more about energy, you'll find out how accurate your answers were. You don't have to show your answers to anyone.

How many gallons of gasoline would you guess your family uses in a year? _____ gallons

How many dollars worth of electricity? _____ dollars

How many dollars worth of natural gas? _____ dollars

How many dollars worth of fuel oil? _____ dollars

If you can think of any other kinds of energy you use, write them here: _____

What single use consumes the most energy in your home? _____

Second biggest? _____

Does your family have a car? How many miles per gallon does it get? _____ mpg

Do you have a hot water heater? What temperature is its thermostat set at? _____ degrees F

Is your home heating controlled by a thermostat? In the winter, what is its setting? _____ degrees F

Do you have air conditioning? In the summer, what is its setting? _____ degrees F

Through what part of your home can heat escape most easily? _____

Here are the six biggest sources of the energy used in the U.S. Answer each of the following questions by writing the number for one of the energy sources.

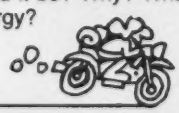
1. **coal**
2. **hydroelectricity**
3. **natural gas**
4. **nuclear fission**
5. **petroleum**

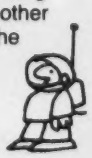
Which energy source provided the most energy last year? _____ Which energy source was most important in generating electricity? _____ Which energy source do we produce the most of in this country? _____ Which energy source provided most of our energy in 1940? _____ Almost half of the energy from one of the sources came from other countries. Which source? _____ Which energy source provides almost all the energy used to move people and things around the country? _____ Which energy sources came from sunlight? _____ Which energy source is most important in heating homes in the part of the country where you live? _____ Which energy sources were used to produce the electricity you use in your home? _____

On a separate piece of paper, answer these questions.

Tuck the paper into this book and save it until your class finishes studying energy. Then see if your ideas have changed.

What would be the best thing your family could do to reduce your energy costs for transportation? What would be the best thing your family could do to reduce your energy costs for heating (and cooling) your home? If you were going to replace one appliance in your home with another that did the same job but used less energy, what would it be? Why? What do you think is the most important thing the country should do about energy?





In all the universe there is only matter

...and ENERGY

light energy
heat energy
chemical energy
the energy of motion
electrical energy

Many kinds of energy but it's all energy. Energy changes from one form to another — but it can't be created or destroyed. (Under some very special conditions, matter can be changed into energy — for example in the sun or an atomic bomb.) Mostly though, when energy seems to be made or to disappear it's just changing from one form to another.

To use energy, people almost always have to change it from one form to another. Often we use machines to do this. A candle changes chemical energy to heat and light. An automobile changes chemical energy in gasoline to heat and the heat into motion. What kind of energy is each person in the drawing starting with, and what kind are they trying to get?

chemical

Energy... rules of the game

Whenever we change energy from one form to another, part of the energy becomes heat. When you turn on a fan to cool yourself on a hot day, you don't want heat. You want to change electrical energy to the motion of air. But what happens? The electric motor gets hot. Part of the electricity is changing to heat.

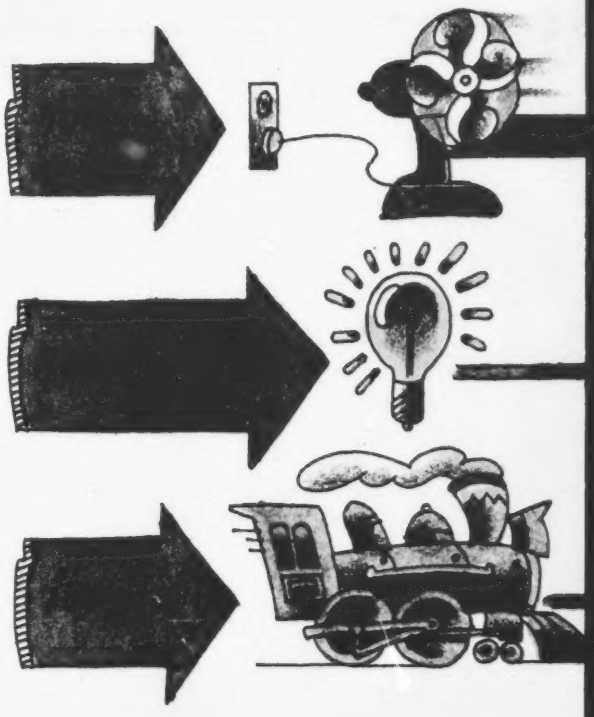
We want the chemical energy stored in gasoline to move the motorcycle. But a lot of the energy becomes heat in the exhaust or engine.

We want the light energy shining on a green leaf of corn to be stored as chemical energy in the plant. But most of it just warms the leaf. As time goes on, more and more of the energy in the universe gets changed to heat.

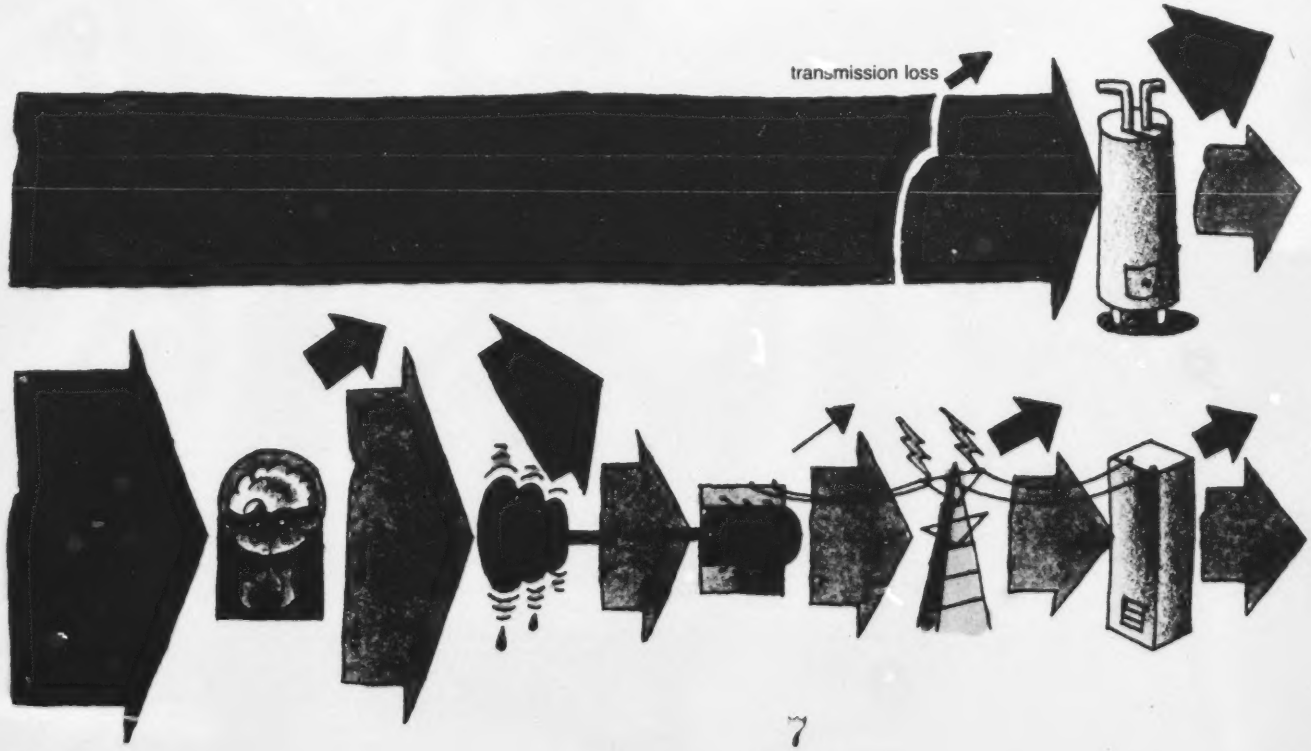
When we change energy from one form to another, only part of the energy we put in will come out in the form we want it. How much we can get is called efficiency. The efficiency of the fan motor is about 35%; of the motorcycle about 20%; of the leaf about 3%.

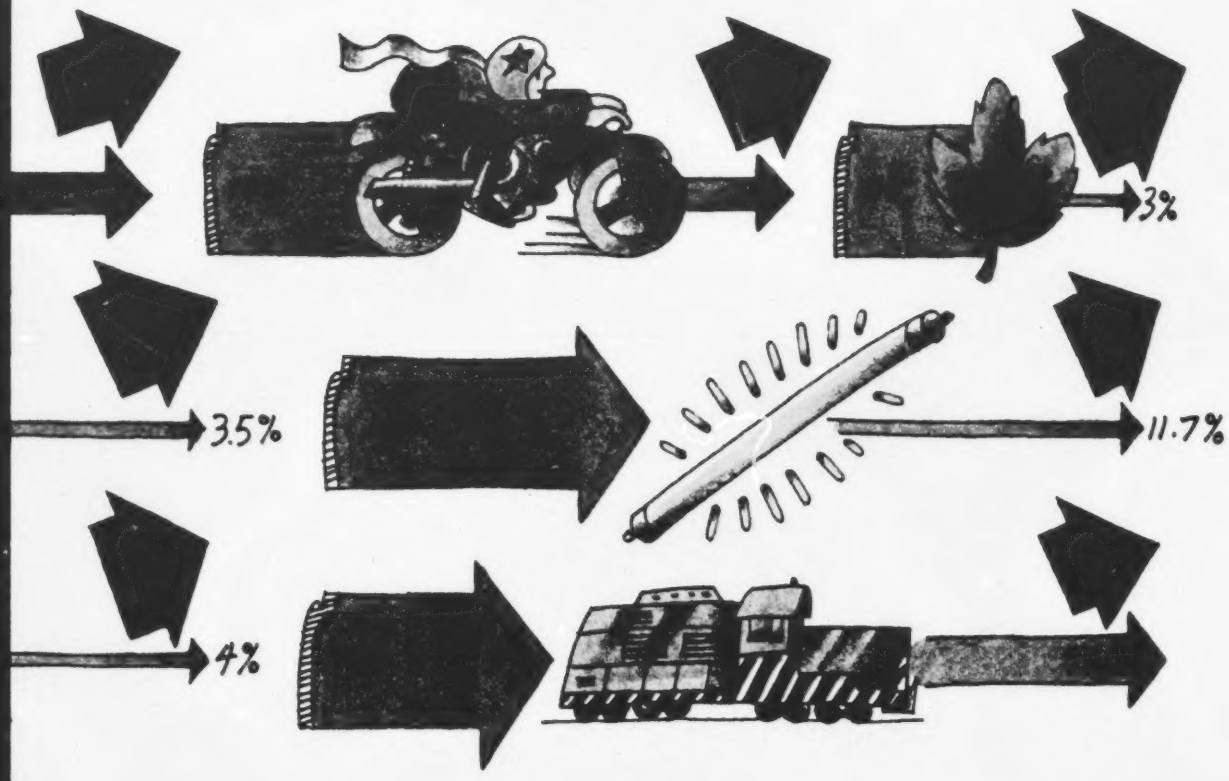
Inventors try to find more efficient ways of using energy. An incandescent bulb changes from 2.5% to 4.5% of the electrical energy it receives into visible light. 8.5% to 15% of the electricity entering a fluorescent lamp is changed to visible light.

Coal-burning steam locomotives had an efficiency as low as 4%. Modern diesel electrics have efficiencies of around 35%.



System efficiency





Energy flows. When you look at the efficiency of only part of an energy flow, you can get fooled. For example, an electric water heater has an efficiency of about 79% and a gas water heater about 46%. The electric heater looks better.

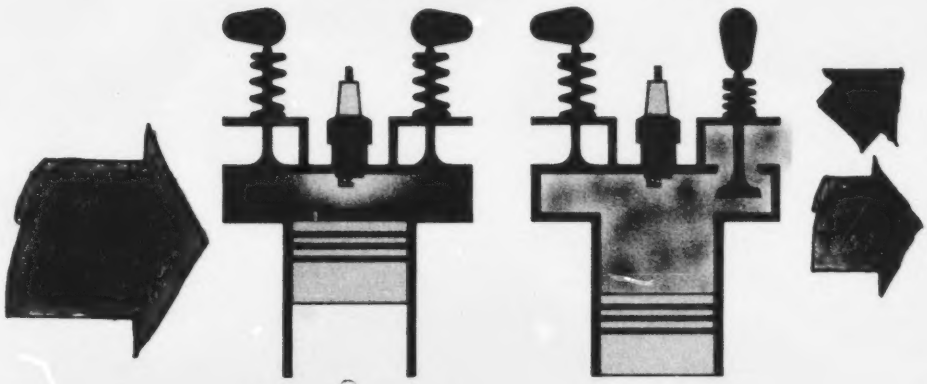
But suppose that electricity came from a power plant that burned gas (15% of the electricity used in the United States last year did). The efficiency of the *boiler* was probably around 88%; of the *turbine* 47%; of the *generator* 99%; and of the *wires* and other parts of the transmission system about 80%. The result is that the whole electrical system plus water heater has an efficiency of around 26%. Nearly twice the gas needed for the gas heater must be burned to heat water in the electric heater.

Heat Engines

Steam engines, gasoline and diesel engines, steam and gas turbines; all are *heat engines*. All of them change heat to motion. In all of them, heat moves from a hot place (like a boiler or combustion chamber) to a colder place (like a condenser or the air).

No heat engine can be 100% efficient. How much of the heat can be changed to motion depends on the difference between the temperatures of the hot place and the cold place.

For example, an engine with 1000°F gas in the cylinder and room temperature exhaust has a maximum possible efficiency of about 60%. The efficiency of heat engines has mostly been improved by raising the operating temperature; the higher the better.



Our Sun...

500,000,000,000,000,000,-000,000 Horsepower!

That's the rate at which the sun is sending out energy into space, mostly as light. At noon on the earth's surface, a square yard gets a little less than one horsepower worth of this light (a little more than 500 watts). The sun has been putting out energy at this rate for the last 4 billion years, and will probably go on doing it for another 4 billion years.

Anything light shines on absorbs part of the light energy, changing it to heat. Sunlight shining on the earth warms the air, the land, the water.

Wind Cycle

Because some parts of the earth get more sunlight than others, they are hotter. Air over warm land and sea areas is heated and rises, and colder air comes in to take its place.

All winds — sea breezes or hurricanes — are powered by the sun's warming the land and ocean.
A windmill pumping water on a Texas ranch; the ship that brought Columbus to the New World — the energy for these came from sunlight.

energy superstar

Photosynthesis

is the process green plants use to store light energy, in the form of the chemical energy we call food. All the energy of our bodies comes from food, and so from sunlight that once struck a green leaf.

Water Cycle

When sunlight warms water, it helps some of the water evaporate. The water vapor is blown about by the wind, and sometimes makes clouds and falls as rain. The rain water collects in rivers and rushes down to the sea, to be lifted again as water vapor to the mountaintops. The electrical energy we get from hydroelectric plants, like Hoover Dam, was once the energy of sunlight.

The sun's energy is the power behind the natural cycles that make our world the way it is. The rivers run, the winds blow, the seasons change, generations of living things succeed each other, all because the materials are recycled and the energy flows from a sun that just keeps on sending us energy.

...provides

How Plants Trap Energy

Green plants bring water from their roots up to the leaves. Water is made of the chemical elements hydrogen and oxygen. From the air, the plant's leaves take in carbon dioxide, a gas made of carbon and oxygen. The energy of sunlight is used to join carbon (from carbon dioxide) and hydrogen and oxygen (from water) to make a molecule of carbohydrate.

Sugars and starches are carbohydrates. There is some oxygen left over which the leaf gives off to the air — that's oxygen we need to breathe. The plant uses the carbohydrates for its own energy needs, like building the big molecules it needs to grow.

Food Energy

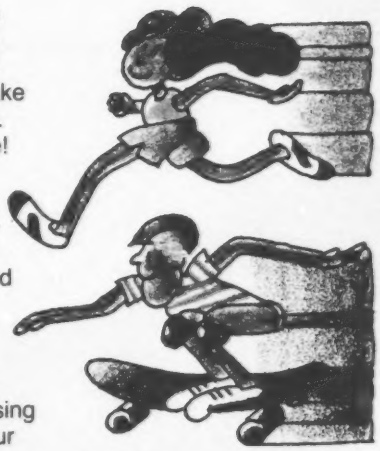
Passing Energy Along

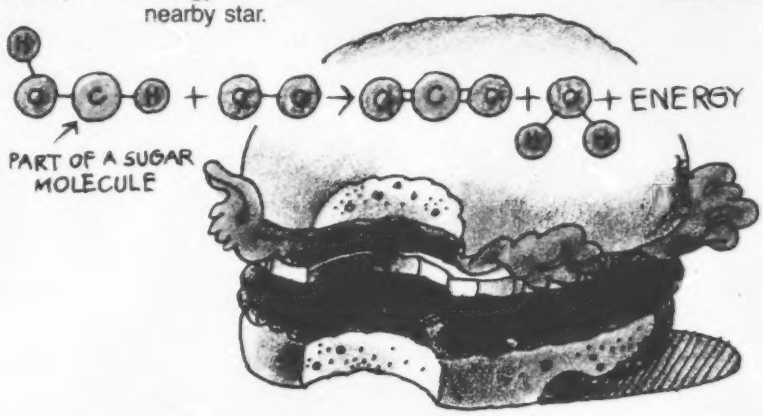
The molecules of the plant are stored chemical energy. If an insect comes along and eats the leaf, it gets the chemical energy that was in the plant's substances. It may use part of that energy to fly to the next leaf, or it may be eaten by a bird, who gets the chemical energy in the insect's substances. This passing along of food energy from plant to animal to animal creates a food chain. The animal at the top of the food chain doesn't get all the energy of sunlight the green plants at the bottom of the food chain took in. Most of it has been changed to heat by animals along the way.

People are at the top of many food chains. If that chain is wheat-cow-people, you will get only a tenth of the food energy you would have gotten by eating the wheat itself. (Beef does supply needed proteins that wheat doesn't, however).

Cashing in Your Chips

You get energy out of the food you eat by breaking down big food molecules and adding oxygen to make water and carbon dioxide. Water and carbon dioxide! Isn't that what the plant started with? Yes, people just run photosynthesis backwards to get out the energy that started with light, giving back to the air the carbon dioxide the plants need. When you run, breathe, think or snore, you are using energy that came from our nearby star.



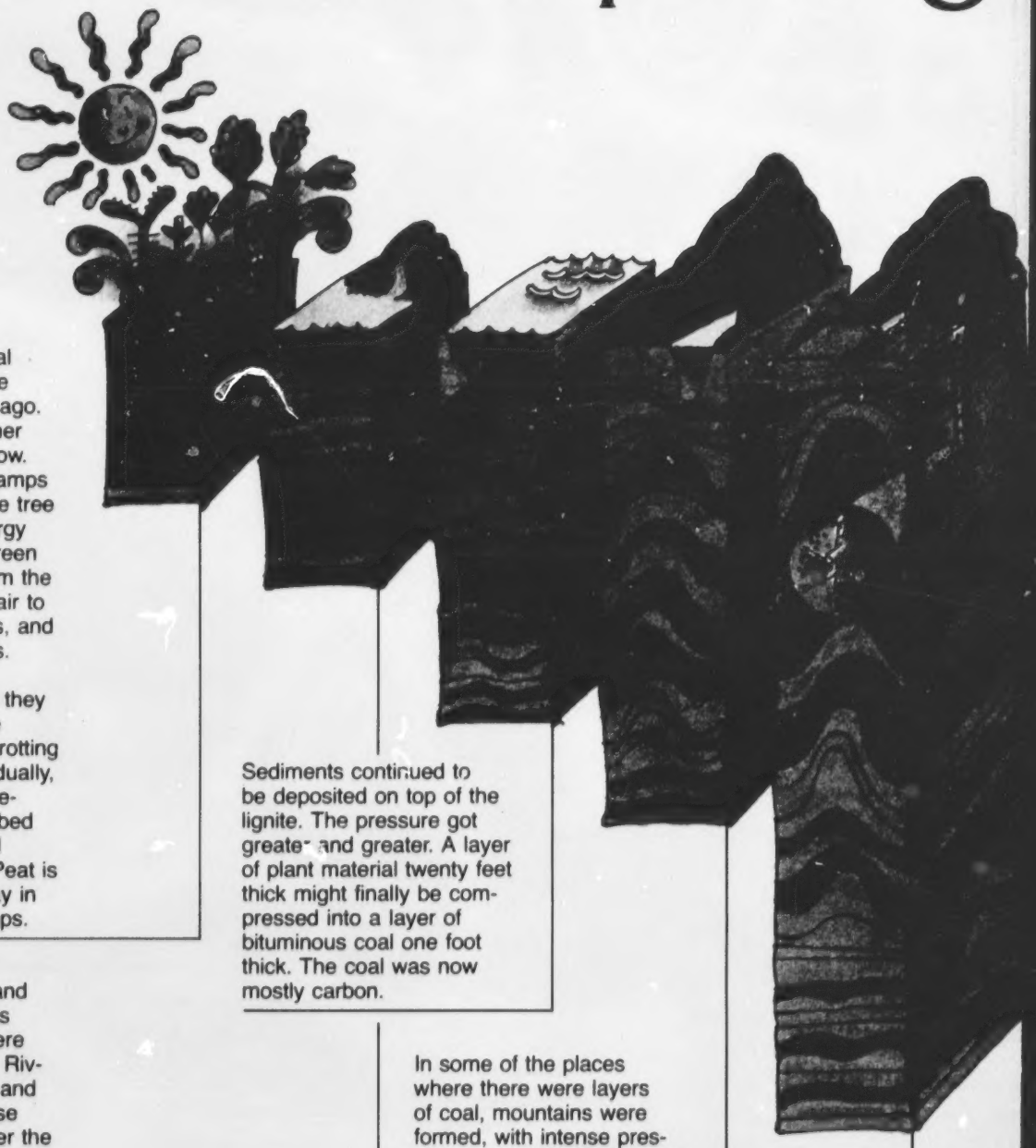


Takes More Than Sunlight to Set the Table

The only energy you can get from your food is the light energy that fell on green leaves. But other kinds of energy go into growing our food and carrying it to our table — about ten calories for every calorie of food energy. On the farm, it takes 3 gallons of petroleum to raise a hog, 3 cups to raise a chicken, and 30 gallons to raise an acre of peanuts. About a fourth of the energy used to feed America is used on the farm. The rest is used to transport, refrigerate, process, dry, package, and cook. Almost all of this energy comes from petroleum and natural gas.

Fossil Fuels ... super long

coal



Most of the earth's coal originated around three hundred million years ago. The climate was warmer and wetter than it is now. Many places were swamps where green plants like tree ferns grew. Using energy from sunlight, these green plants took carbon from the carbon dioxide in the air to make sugars, starches, and other plant substances.

When the plants died, they fell into the water. The water kept them from rotting away completely. Gradually, a thick layer of plant remains built up on the bed of the swamp. We call these remains, peat. Peat is still being formed today in some bogs and swamps.

As time passed, the land changed. Shallow seas covered the place where the swamp had been. Rivers swept mud, sand, and clay into the sea. These sediments washed over the layers of peat. The layers of sediments grew thicker as more sand or clay was deposited. The weight of these layers squeezed water out of the peat and hardened it. It became a low-grade form of coal called lignite.

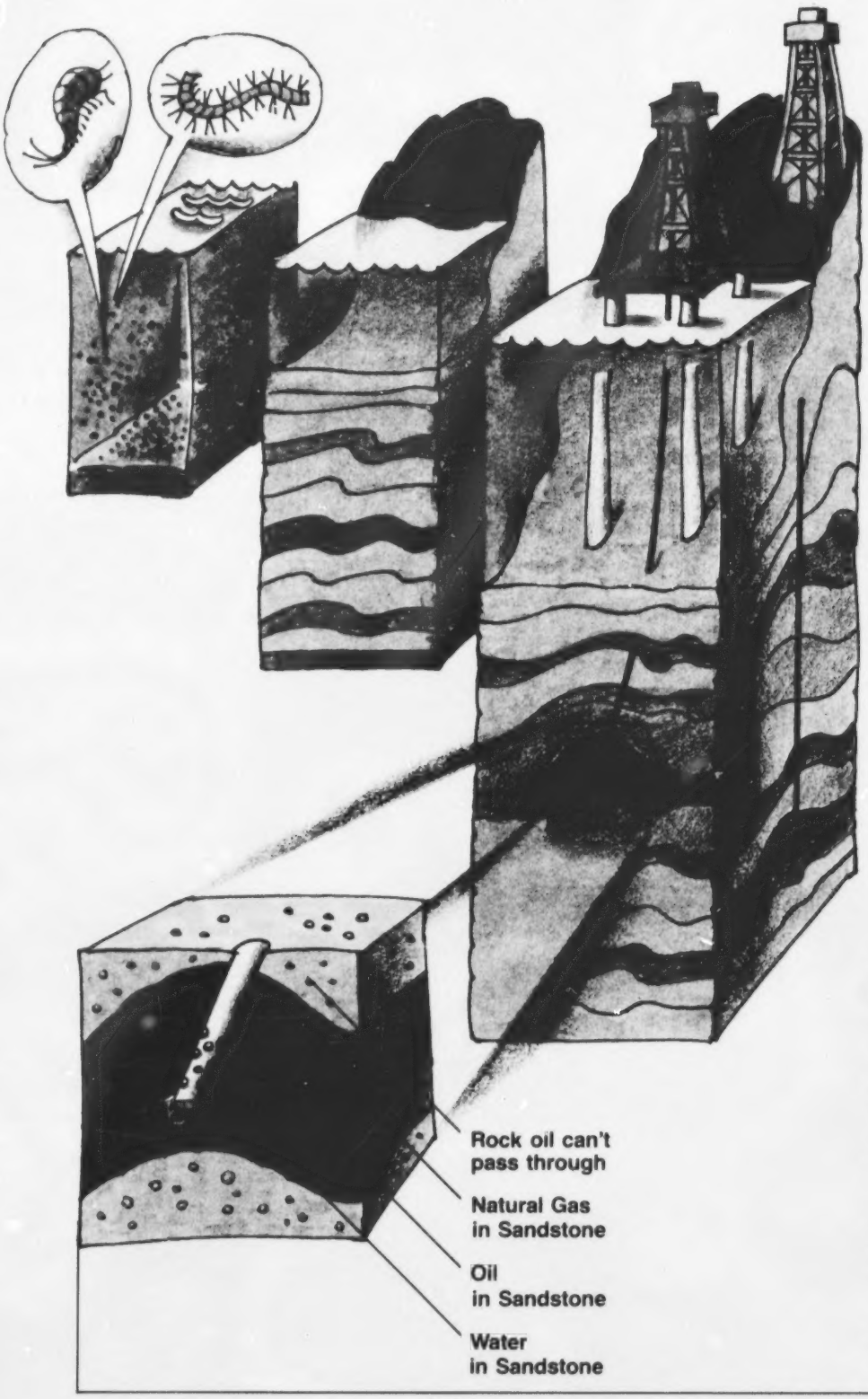
Sediments continued to be deposited on top of the lignite. The pressure got greater and greater. A layer of plant material twenty feet thick might finally be compressed into a layer of bituminous coal one foot thick. The coal was now mostly carbon.

In some of the places where there were layers of coal, mountains were formed, with intense pressure and folding of the rock layers. This created the highest grade coal, anthracite. It is 90% pure carbon.

Today, we are mining the remains of green plants that grew before there were dinosaurs. The energy we get by burning coal comes from sunlight that fell on a swamp millions of years ago.

13

stored-up food energy



oil & gas

We don't know as much about how petroleum and natural gas are formed as we do about coal's formation. This is what most geologists think happened:

The ocean is the home of many floating microscopic plants and animals. (Most of our oxygen supply comes from these green plants, not from land plants.) When these living things die, they may sink to the bottom and get mixed with sediments.

The sediments are covered with more sediments. Eventually, the deeper sediments become rocks like sandstone. Between the grains of sand in the sandstone are tiny spaces. The substances from the animals fill these spaces.

Heat and pressure change the plant and animal remains. Part often becomes natural gas dissolved in the crude oil. The different substances from different plants and animals, and different heats and pressures in the earth, explain why crude oil is such a jumble of hundreds of different chemicals.

Today, we drill down to reach a sedimentary rock in which oil might be trapped. One of the clues geologists use to locate oil are the fossils of ocean animals in the surrounding rock layers.

Coal: the once and

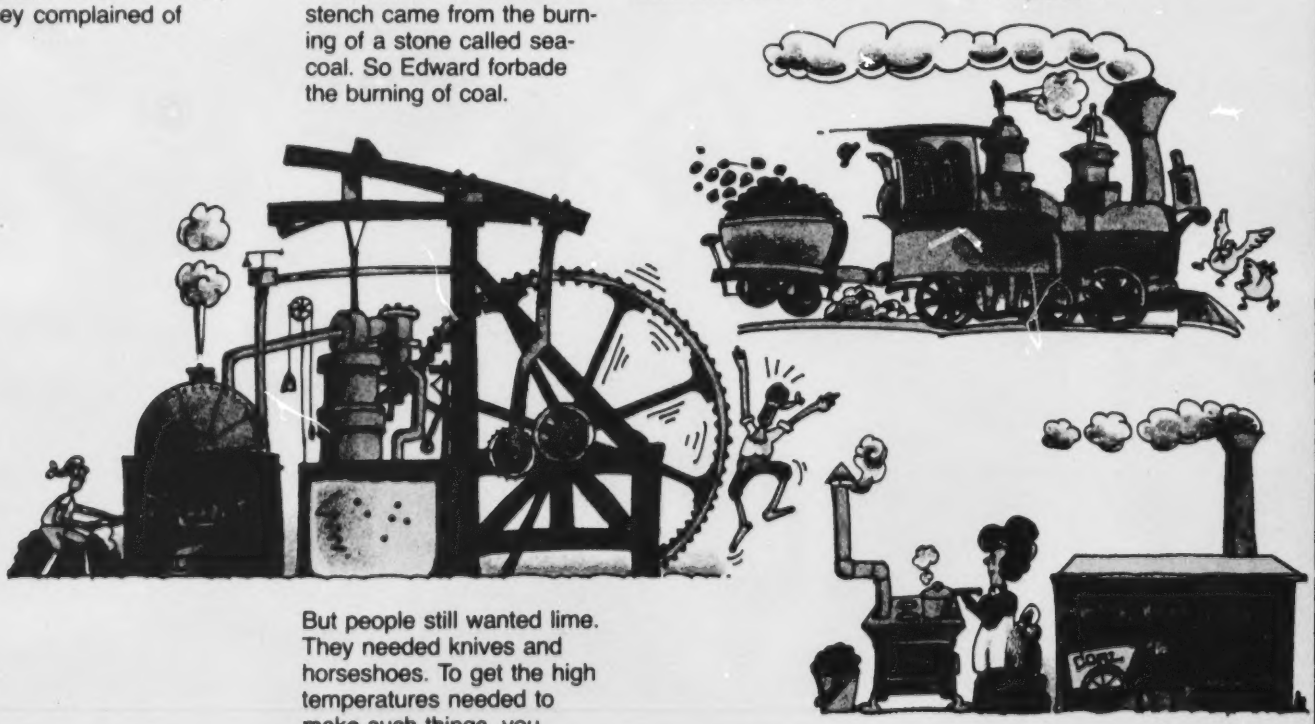
About 650 years ago, an English king named Edward I made a clean air order. Whenever Edward's officials visited London, they complained of the terrible smells coming from the workshops of the blacksmiths and the people who heated limestone to make lime for mortar. The stench came from the burning of a stone called sea-coal. So Edward forbade the burning of coal.

But people still wanted lime. They needed knives and horseshoes. To get the high temperatures needed to make such things, you needed either coal or charcoal—and wood to make charcoal was getting scarcer and scarcer. Finally the law was changed to permit the burning of coal. People were able to make the things they wanted, and London got smokier and smokier.

Charcoal was also needed to make iron from its ore. Around 1709, an English ironmaster named Abraham Darby perfected a way of using coal to make good pig iron. His method spread slowly, and others added their ideas. By 1800, the English had mastered ways of making iron and steel using coal. Cheap, plentiful coal made iron plentiful, and plentiful iron—strong, tough, durable—led to an explosion in people's use of tools and machines.

Coal powered a second revolution: the steam engine. Around 1780, inventors like James Watt began to build practical machines that changed the heat from burning coal into mechanical energy. For the first time, a way had been found to make a fuel do the work instead of muscles.

In the United States, coal got off to a slow start. Our vast virgin forests provided a plentiful supply of cheap fuel wood; not until 1883 did we burn as much coal as wood. Railroads were the biggest single cause of this change. They needed steel for tracks and rolling stock, and fuel for locomotives. The railroads also helped increase coal consumption by carrying coal cheaply to all parts of the nation, and to ports from which it could be exported.



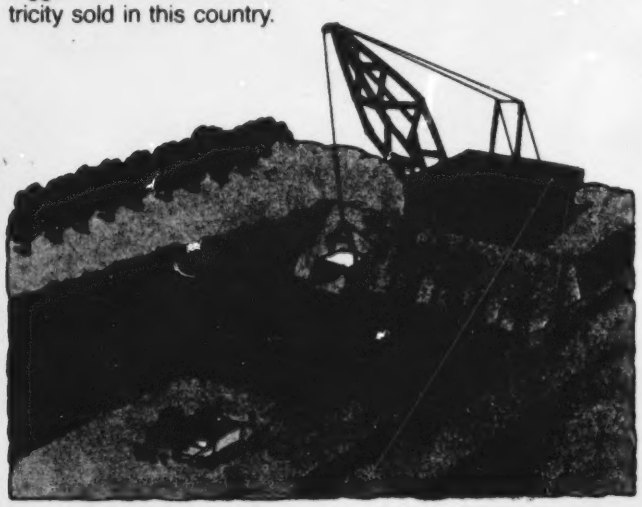
Modern times were built with coal. Coal ran the factories and moved the people and freight. In pot-bellied stoves, it heated country stores, and it cooked meals in homes. Coal was king!

future king?

In the 1950's, coal was replaced as our chief energy source by petroleum and — increasingly — natural gas, because those fuels are much easier to transport and burn.

Most of the coal we mine today is burned under huge boilers to generate electricity. Coal is by far the biggest source of the electricity sold in this country.

Our country is blessed with a vast supply of coal, enough to last for hundreds of years at the rate we're using it. It is our biggest mineral energy reserve (next to uranium, if that were used in breeder reactors). In the West, large seams of coal lie a few hundred feet below the surface, and are often surface mined.



People like western coal because it has little sulfur. Burning sulfur can cause air pollution. Most eastern coal is high in sulfur and lies deeper in the ground, so that it has to be mined underground. Underground mining is less efficient than surface mining, even including the need to reclaim the surface land when the mine is closed. However, new underground mining methods have been developed that get out more of the coal than we used to, with less danger to the miners.

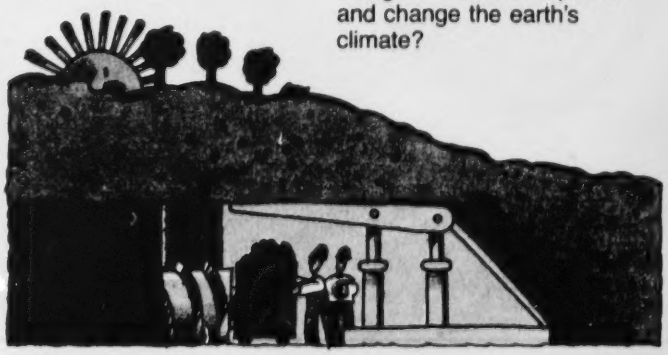
Major coal deposits in the U. S. A.

Since we have so much coal — perhaps 50 times more coal than oil — why don't we use more of it? In the short run, one reason is that to open new coal mines and build coal-burning equipment is a costly, time-consuming business. In the long run, the big problems are how hard it is to move and burn coal — and pollution.

New ways of shipping coal more cheaply, even by pipeline, are being tried. In pilot plants, we are making other fuels from coal, such as gasoline and pipeline gas. Such fuels would be easier to move and burn than coal itself. But the processes we now have make fuels that cost more than we're paying today. Can cheaper processes be found?

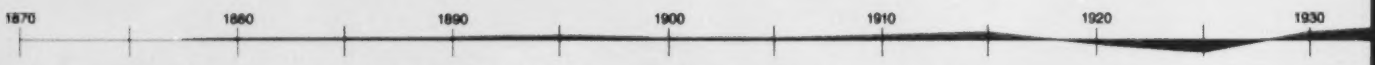
New ways of burning coal, like fluidized bed combustion, promise less pollution and hotter, more efficient fires, and will make it easier to burn coal in small plants. Can these techniques be proven commercially?

Air pollution equipment is removing most of the pollution that once darkened industrial cities. But the problem of cleaning up coal at an acceptable price is not yet solved. In the long run, the most stubborn pollutant may turn out to be carbon dioxide. Is what many scientists fear true? Will relying on coal increase the percentage of this gas in the atmosphere and change the earth's climate?

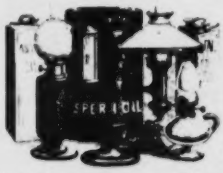


For decades, coal has been ignored. Now we need to find answers to questions like these as soon as possible. If we can, perhaps one day coal will be king again.

Oil & Gas Production & Consumption



In 1850, artificial light was expensive. Most people used lamps that burned turpentine, alcohol, lard oil, oil made by heating coal, or, best of all, clean-burning whale oil. Unfortunately, a gallon of whale oil cost two days' wages.



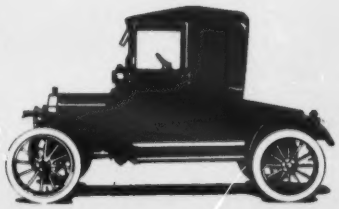
In some places in the earth, an oily substance seeps to the surface of creeks and pools. Some manufacturers who made lamp oil by distilling coal tried distilling this "rock oil." It made a fine lamp oil, but skimming it off creeks was too difficult.

Brine well drillers tried a different way of getting the "petroleum." In 1859, in Pennsylvania, they struck oil at 69½ feet. Drilling for oil was the cheapest way the world had ever found of getting a concentrated energy source.

Crude oil is a complex mixture of many different substances. Refiners separated them by distilling the oil. The useful part, kerosene, was sold for lamps. The useless parts, like gasoline, were mostly thrown away.

Oil production boomed. People from China to Peru wanted kerosene for their lamps. American oilmen sold it to them. America became the leader in oil production, refining, and shipping know-how, a role we still have.

Times changed. Electric lights were invented. The horse began to be replaced. Horseless carriages needed a powerful fuel that could be burned in a lightweight engine. Gasoline was tried and it worked. Henry Ford's cheap Model T put America on wheels.

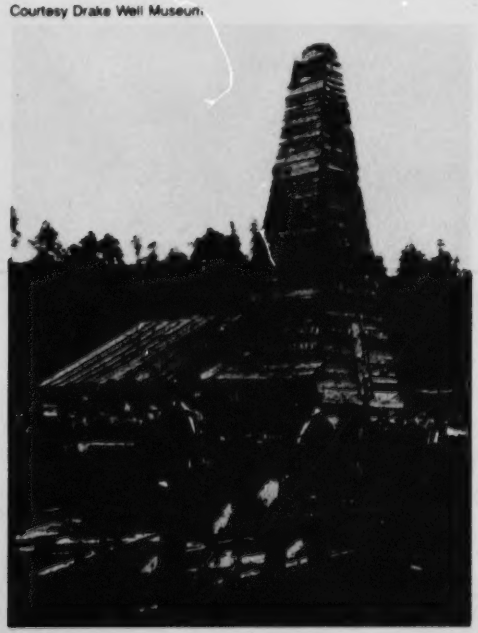


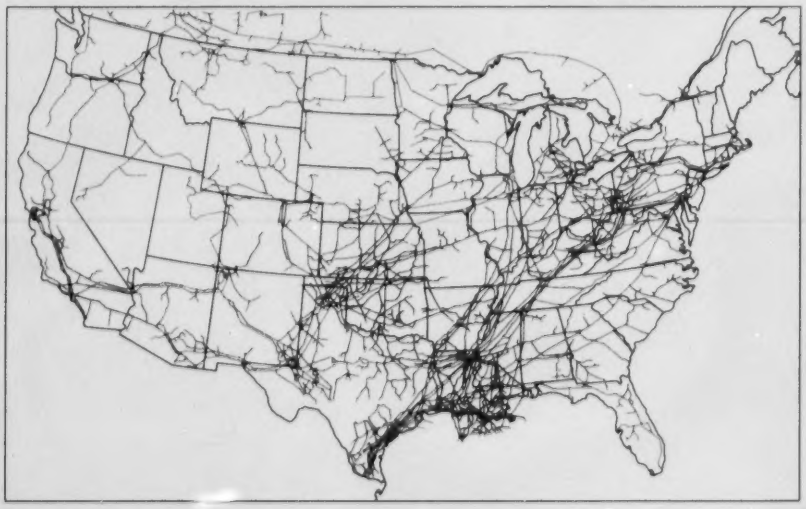
Now people wanted more gasoline, less kerosene, from the crude oil. Refiners asked chemists to find ways of remaking the crude oil molecules into the molecules people wanted to buy. The chemists did, and went on to invent ways of making new substances from petroleum. In the 1930s appeared synthetic rubbers like neoprene, synthetic fibers like nylon, and plastics like polystyrene. The refinery became a more and more complicated chemical factory.

Where oil was found, natural gas was also, but it was harder to get gas to market. Mile by mile, pipelines were built from the oil fields to the nation's homes and factories. Clean-burning natural gas began to replace coal.

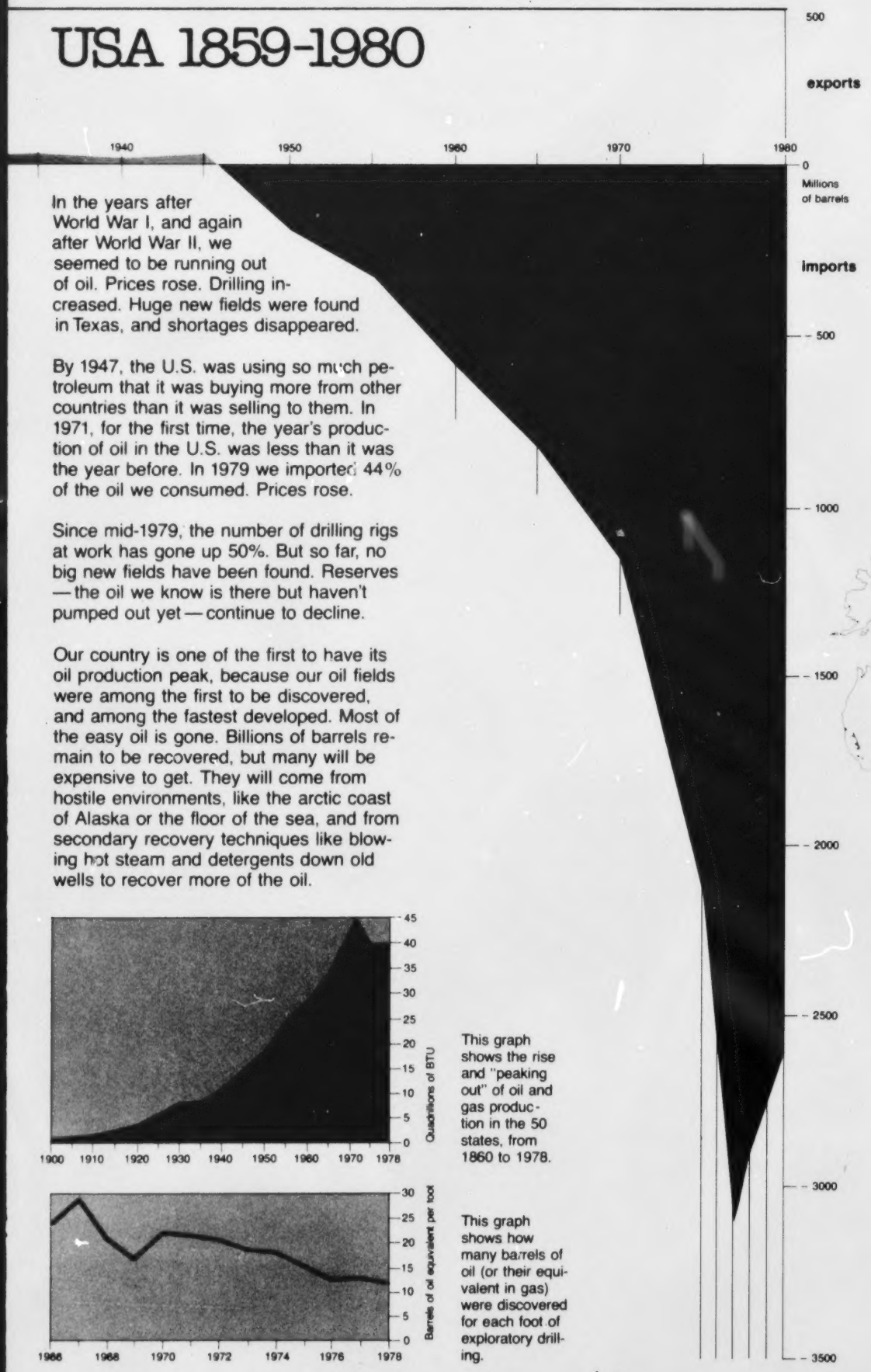
The two maps be ow show principal natural gas pipeline systems in the United States for 1935 and 1978.

Courtesy Drake Well Museum





USA 1859-1980



In the years after World War I, and again after World War II, we seemed to be running out of oil. Prices rose. Drilling increased. Huge new fields were found in Texas, and shortages disappeared.

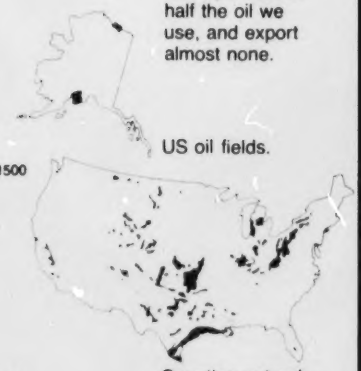
By 1947, the U.S. was using so much petroleum that it was buying more from other countries than it was selling to them. In 1971, for the first time, the year's production of oil in the U.S. was less than it was the year before. In 1979 we imported 44% of the oil we consumed. Prices rose.

Since mid-1979, the number of drilling rigs at work has gone up 50%. But so far, no big new fields have been found. Reserves — the oil we know is there but haven't pumped out yet — continue to decline.

Our country is one of the first to have its oil production peak, because our oil fields were among the first to be discovered, and among the fastest developed. Most of the easy oil is gone. Billions of barrels remain to be recovered, but many will be expensive to get. They will come from hostile environments, like the arctic coast of Alaska or the floor of the sea, and from secondary recovery techniques like blowing hot steam and detergents down old wells to recover more of the oil.

This graph shows how the U.S. changed from a net exporter of oil to a net importer.

In the years before 1880, U.S. exports filled more than 80% of other countries' demand for oil, but the amount was too small to be visible on this graph. From 1885 to 1929, U.S. exports provided about a third of the rest of the world's needs, and the U.S. was the biggest exporter. By 1947, we consumed more oil than we produced. Today, we import about half the oil we use, and export almost none.



US oil fields.

This graph shows the rise and "peaking out" of oil and gas production in the 50 states, from 1860 to 1978.

This graph shows how many barrels of oil (or their equivalent in gas) were discovered for each foot of exploratory drilling.

Counting natural gas as its heating equivalent in crude oil, geologists estimate that there are 49 billion barrels of proved reserves, inferred resources, and undiscovered resources in Alaska, 75 offshore in the U.S. and Alaska, and 203 Bbbls on land in the "lower 48."

The actual amount of oil and gas that will be recovered depends on how much it is worth to us. The higher the price, the greater the quantity that is economically recoverable.

Energy from Nuclear Fission

Almost everything is made out of tiny bits of matter called atoms. An atom has two parts: in the center a **nucleus,** and around the nucleus a cloud of constantly moving **electrons.** This is one kind of diagram of an atom:

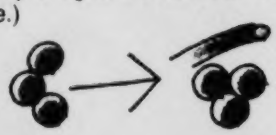
The electrons are very important in ordinary chemical reactions like burning, but "atomic" energy comes from changes in the nucleus. The nucleus contains two kinds of atomic particles: the proton and the neutron. The number of protons in a nucleus decides which chemical element the atom is.

hydrogen 1 proton **helium** 2 protons **carbon** 6 protons **oxygen** 8 protons

Here are three nuclei. What element are they?

They are all hydrogen, because they all have one proton. Yet they are different, because they have different numbers of neutrons. We call these **isotopes** of hydrogen.

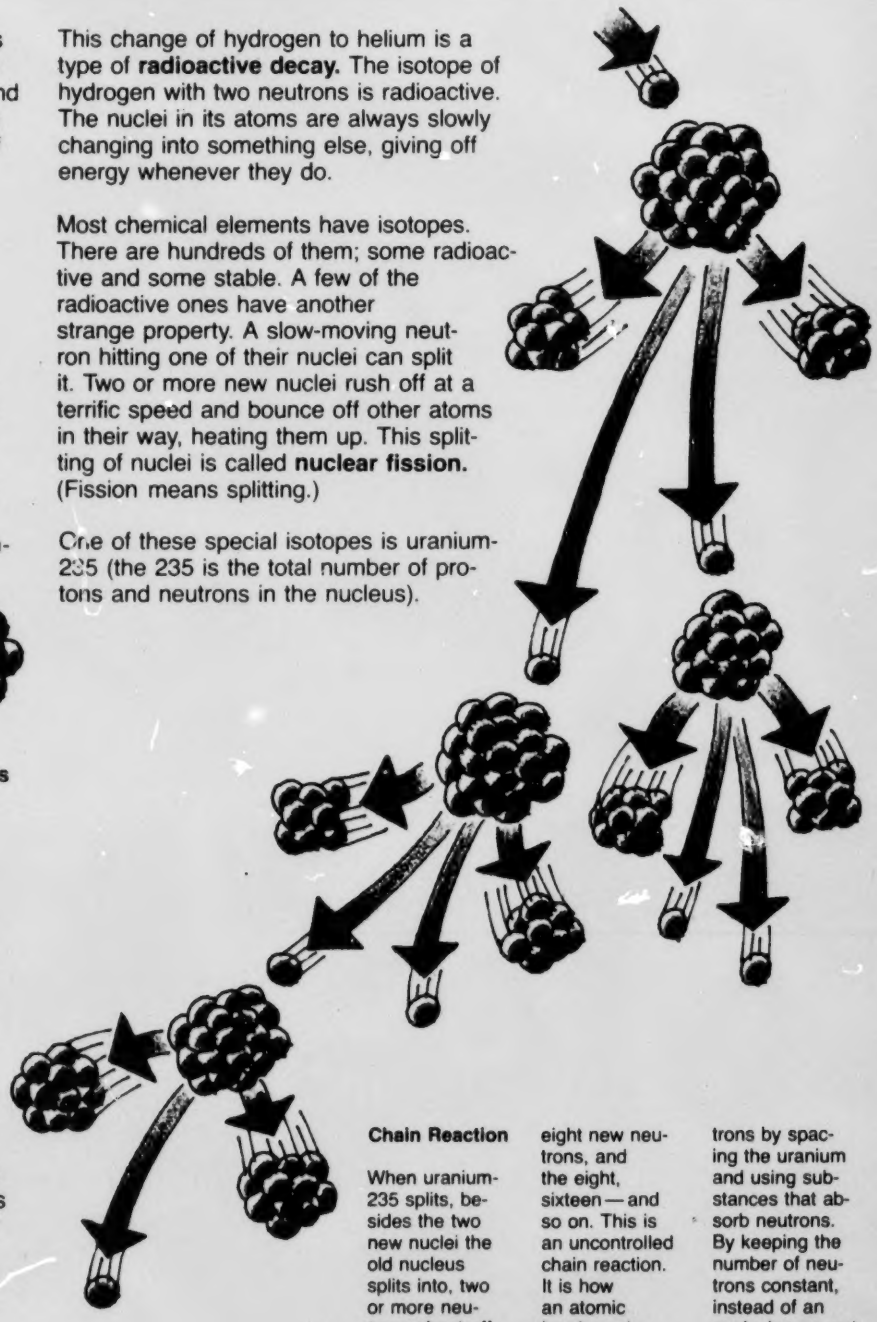
The hydrogen isotope with two neutrons does an amazing thing: without warning, one of these nuclei can suddenly change into another element. One of the neutrons disappears, and a proton appears. Since the new nucleus has two protons, it is helium, not hydrogen. At the same time, an electron shoots out of the nucleus at very high speed. (This electron used to be called a beta ray. Since it really isn't like a ray of light, we now call it a beta particle.)



This change of hydrogen to helium is a type of **radioactive decay.** The isotope of hydrogen with two neutrons is radioactive. The nuclei in its atoms are always slowly changing into something else, giving off energy whenever they do.

Most chemical elements have isotopes. There are hundreds of them; some radioactive and some stable. A few of the radioactive ones have another strange property. A slow-moving neutron hitting one of their nuclei can split it. Two or more new nuclei rush off at a terrific speed and bounce off other atoms in their way, heating them up. This splitting of nuclei is called **nuclear fission.** (Fission means splitting.)

One of these special isotopes is uranium-235 (the 235 is the total number of protons and neutrons in the nucleus).



Chain Reaction

When uranium-235 splits, besides the two new nuclei the old nucleus splits into, two or more neutrons shoot off.

Those two neutrons can hit two more nuclei, making them split, producing four neutrons, and those four can produce eight new neutrons, and the eight, sixteen — and so on. This is an uncontrolled chain reaction. It is how an atomic bomb works.

Instead of letting the neutrons multiply like rabbits, 2, 4, 8, 16, 32, 64, 128, and so forth, we can control the number of neutrons by spacing the uranium and using substances that absorb neutrons. By keeping the number of neutrons constant, instead of an explosion we get a steady supply of heat.

That is the basic idea behind using nuclear energy to get power.

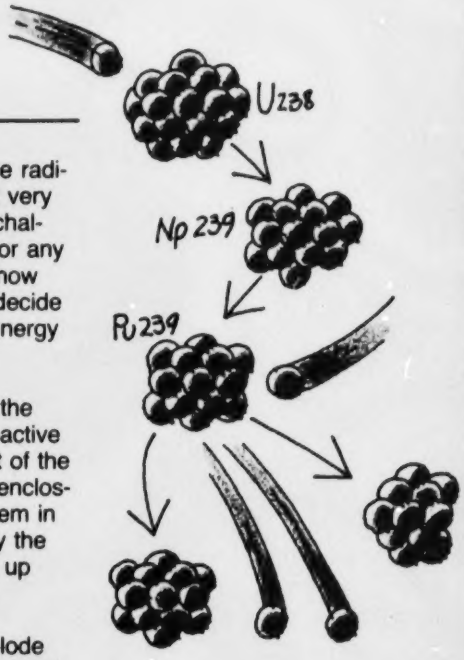
Compared with other ways of making electricity, nuclear fission has some definite advantages. There is no smoke or carbon dioxide. Fewer workers are killed in accidents. Nuclear electricity may be a little cheaper than its main competitor, coal. Probably the biggest advantage is that we have the fuel and know how to get large amounts of electricity from it.

Nuclear power is controversial mainly because of concern about the effects of radioactivity. Radiation can change the molecules in living cells that contain the code for making new cells. Such a change can sometimes lead to a cancer or birth defect years later.

We receive natural radiation all the time, from sources like cosmic rays and the radioactivity of building materials. Reactors add to this radiation by routinely releasing low-level radioactivity (so do coal-burning power plants). The amount each person gets from such planned releases is hundreds of times less than they get from natural radiation, or from other man-made sources like medical X rays. That the radiation is at such a low level makes it very difficult to measure its effects. The challenge in evaluating nuclear energy (or any other energy source) is to estimate how many people it might harm, and to decide whether the good we get from the energy is worth it.

Some of the materials produced as the reactor operates remain highly radioactive for centuries. They must be kept out of the environment. Storage systems, like enclosing materials in glass and storing them in salt mines, have been planned. Only the government has the authority to set up such a system, and so far it hasn't.

Today's nuclear reactors cannot explode like an atomic bomb. The worst imaginable accident would be a "breach of containment," in which both the steel and concrete shells of an operating reactor would crack and release radioactive materials, producing an effect like fallout from an atomic bomb, perhaps worse. Engineers who design reactors try to make this impossible. There has never been a breach of containment in a commercial power reactor.



Breeding New Fuel

Uranium-235 is a very rare isotope. Less than 1% of natural uranium is U-235; the rest is another isotope called uranium-238.

Unfortunately, uranium-238 can't be split by slow-moving neutrons, and so is no good as fuel. But when a nucleus of uranium-238 is hit by a fast moving neutron, it changes to neptunium-239, which quickly turns to plutonium-239.

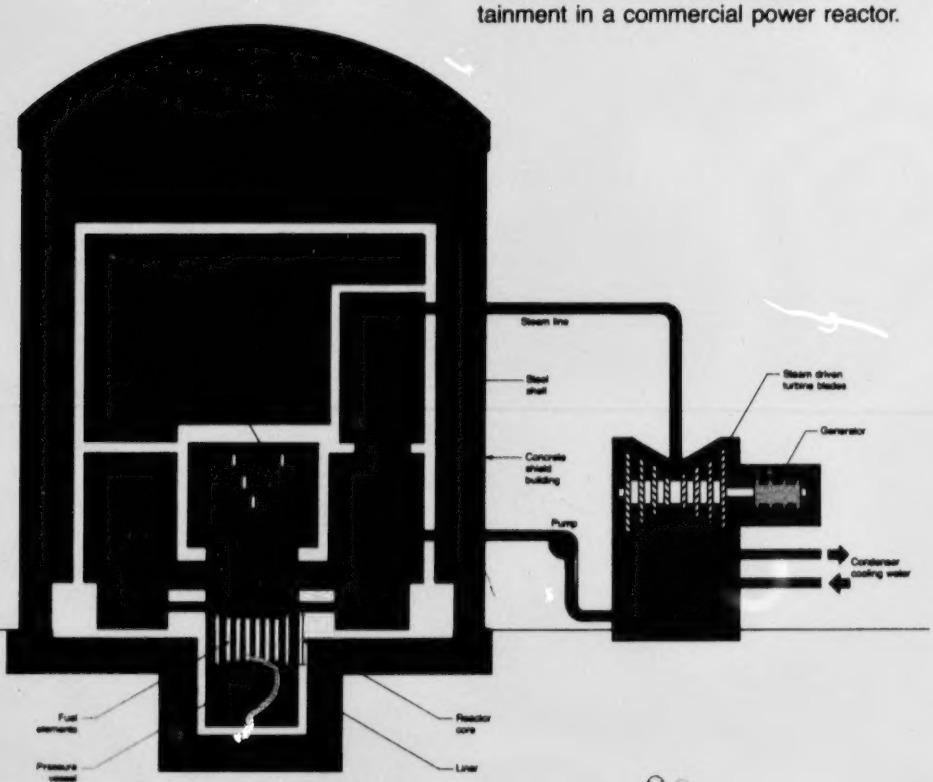
Plutonium 239 can be split by neutrons. So we can use extra neutrons from a reactor to change a substance that can't be used as fuel into a fuel.

Such a reactor is called a breeder reactor.

Pressurized-Water Reactor

Commercial nuclear reactors use the heat from splitting atoms to make steam. The steam is used to run a turbine and generator, just as it is in a coal-burning power plant.

As the plant operates, the fission fragments left over from split uranium atoms accumulate in the fuel. Unfortunately, many of these new nuclei are good at absorbing neutrons, and so stop the reaction. So the fuel must be replaced before all the uranium-235 nuclei have fissioned.



Energy for the Next Ten Thousand Years

In the next ten years, we will not run out of any energy source. Experts think that in the next hundred years world production of oil will decline. In the next thousand years we could run out of coal. And in billions of years, the sun will go out.

We live in the Age of Fossil Fuels, a blip in human history. Yet thanks in part to energy from fossil fuels, in these few centuries the people with fuel have greatly improved their standard of living, learned more, and invented more than in all human history before that.

Many people feel that it is only fair for us to figure out, in the years of fossil fuel abundance that are left, how future generations can use the energy sources that they will have.

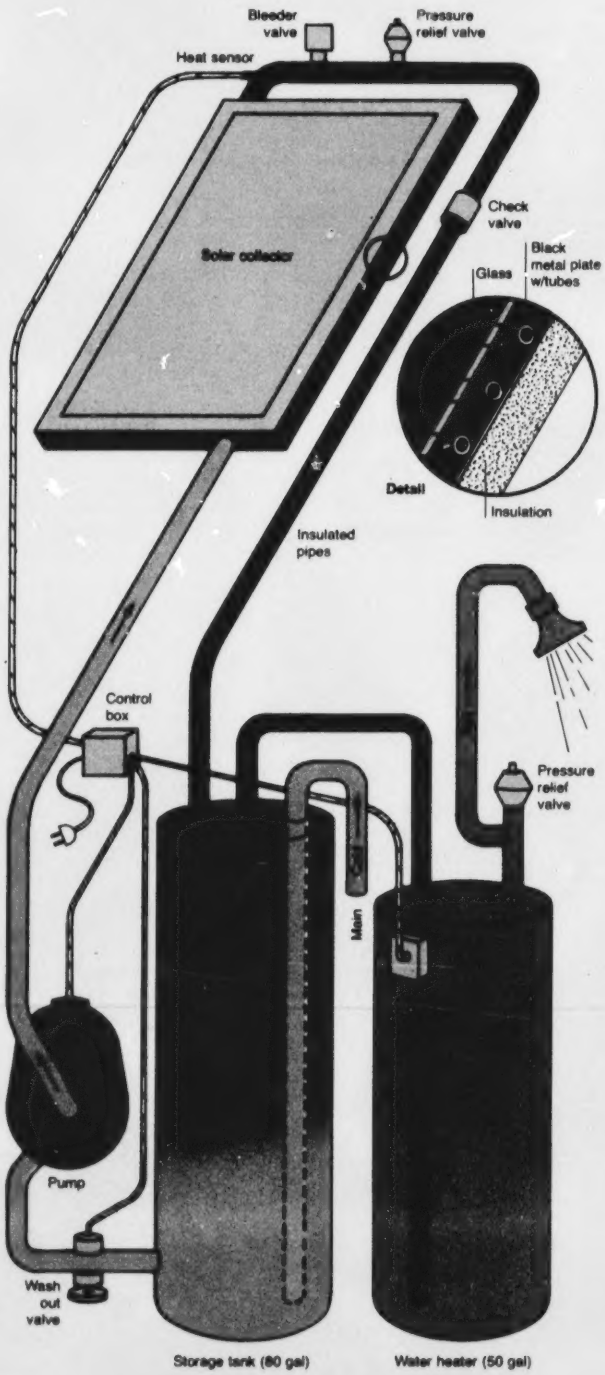
Sunlight is the basic renewable energy source. Eighty years ago, people were building solar collectors. But a solar collection system costs more to build than a furnace producing the same amount of heat. As oil and gas became cheaper and easier to buy, collectors were scrapped.

Today, solar energy is coming back. The prices of fossil fuels are rising, and people are learning cheaper ways of catching the energy of sunlight. No matter where you live, the question is not whether solar energy works, because it can be made to work anywhere, but how much it would cost.

Different energy sources are suited to different uses. Making steel requires very high temperatures and also the element carbon, so coal is ideal. Gas can provide very high temperatures and is clean-burning in simple equipment, so it is a perfect fuel for small urban businesses that need high temperatures.

What is sunlight best suited for? It is easiest to make it provide 70° to 120°F heat. This is very valuable, because almost 70% of the energy consumed in American homes is used to produce low-temperature heat to warm rooms and heat water. If we use sunlight for this, fossil fuels can be saved for uses like running buses and cars.

Active Solar Water Heater



An Active Solar Water Heater

In most parts of the country, solar water heaters can pay for themselves. A typical water heater looks like this:

On the roof is a large, flat black plate. Sunlight warms the plate.

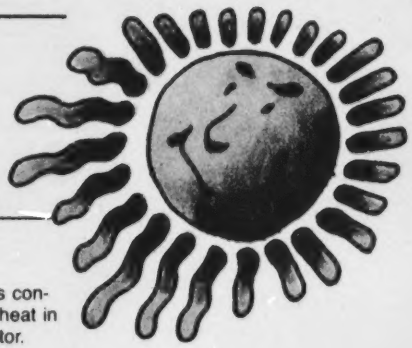
Water circulates through coils in the plate. The flowing water carries away the heat from the plate.

The plate is well-insulated. The insulation on top is clear glass or plastic.

Pumps drive the water to a storage tank in the basement. The storage tank is large and very well-insulated.

A back-up heater that uses electricity or fuel can provide hot water if the storage tank's supply is used up. It is cheaper to do this than to build enough extra collectors and storage tanks to get through the worst possible spells of cold, cloudy, weather.

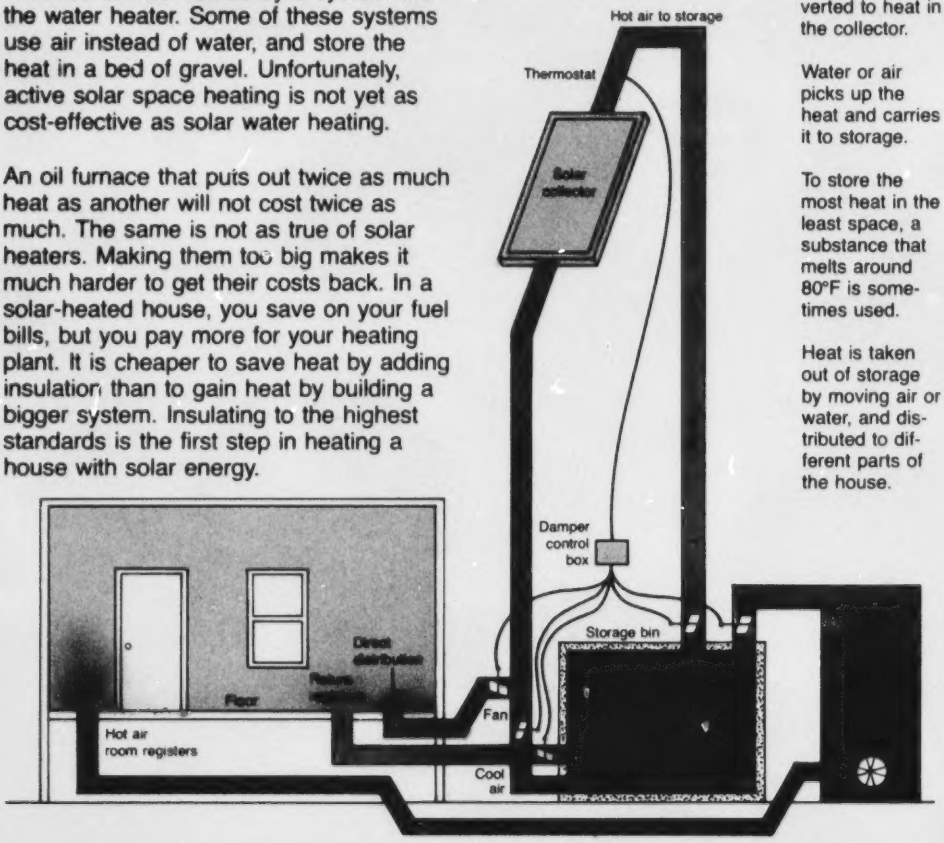
This is called an active system because pumps and controls are used.



Active Solar Space Heating

A house can be heated by a system like the water heater. Some of these systems use air instead of water, and store the heat in a bed of gravel. Unfortunately, active solar space heating is not yet as cost-effective as solar water heating.

An oil furnace that puts out twice as much heat as another will not cost twice as much. The same is not as true of solar heaters. Making them too big makes it much harder to get their costs back. In a solar-heated house, you save on your fuel bills, but you pay more for your heating plant. It is cheaper to save heat by adding insulation than to gain heat by building a bigger system. Insulating to the highest standards is the first step in heating a house with solar energy.



Active
Sunlight is converted to heat in the collector.

Water or air picks up the heat and carries it to storage.

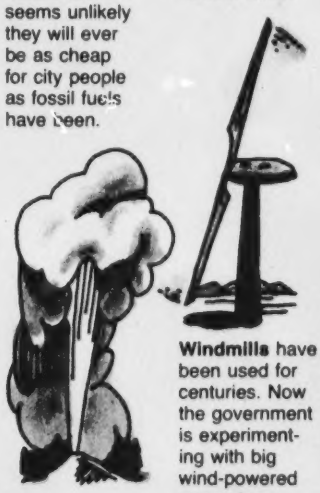
To store the most heat in the least space, a substance that melts around 80°F is sometimes used.

Heat is taken out of storage by moving air or water, and distributed to different parts of the house.

Some Other Renewables

Plants can be grown to make fuels like firewood or alcohol. Such fuels may be very useful in rural areas. It seems unlikely they will ever be as cheap for city people as fossil fuels have been.

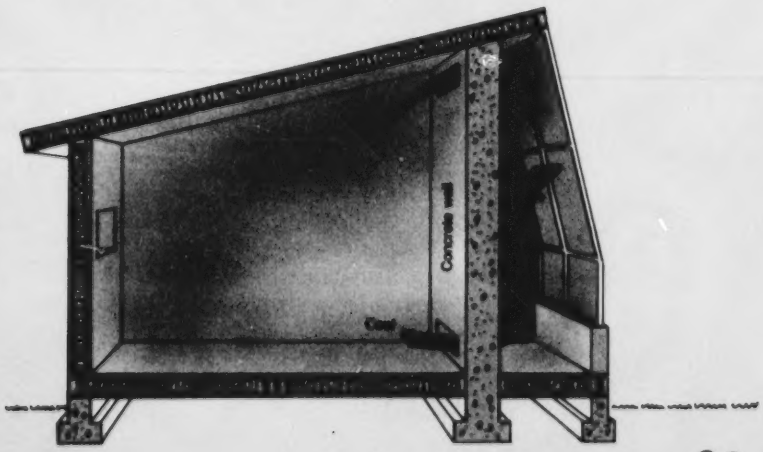
Photovoltaic cells change sunlight directly to electricity. Today they are cheap enough to compete with conventional generators in remote areas.



Windmills have been used for centuries. Now the government is experimenting with big wind-powered generators.

Passive Solar Space Heating

One form of solar heating can be almost free: building a house so that the house itself is the collector.



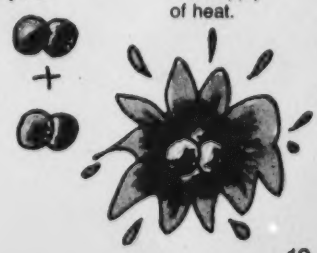
Passive
South-facing windows collect the sunlight. Inside the windows is material that will hold heat, like concrete or drums of water.
The house is very well-insulated, perhaps with earth berming. There are few heat-losing windows on northern sides.

Ventilation is arranged to take advantage of prevailing winds and to exhaust the hottest air in summer.

And Some Not-Quite-Renewable. . .

Geothermal energy provides 7% of San Francisco's electricity. Near there, the earth's heat makes very hot steam. Engineers are working out ways of using the heat from drier and cooler rock layers.

Fusion is the process that powers the sun; two small nuclei join to make a bigger one. Enormously high temperatures are needed. If we can figure out how to do this, we will have an enormous supply of heat.



Energy . . . the more we have . . .

1700

An Iroquois Indian used the heat from burning wood to cook his food, to warm himself in winter, and even to make tools. But to drive his tools — hoes, scrapers, bows — he had to use his own muscle power. The things he needed he could gather in the forest. He didn't need to carry them far or change them much. Some people today live much as the Iroquois did in 1700.

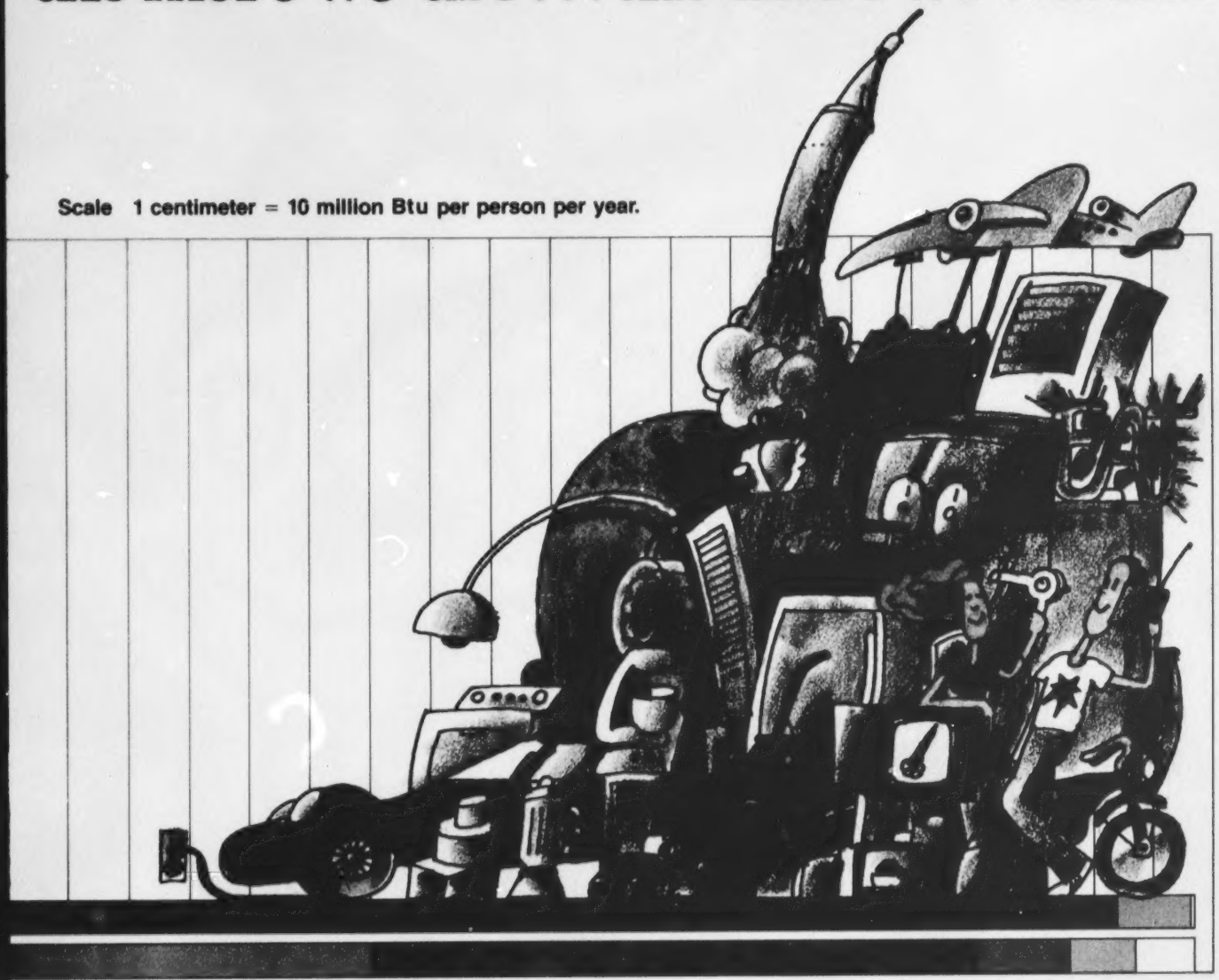
1800

The people of the new nation got almost all their energy from the same sources as the Iroquois did, but new ways of using energy were making their lives easier.

Firewood warmed their houses and shops and cooked their meals — but an iron Franklin Stove got a lot more useful heat from a log than an Indian campfire could get. Food energy produced muscle power, pulling plows for farming and wagons and carriages to transport goods and people. A human treadmill powered the first American factory, but a waterwheel soon replaced it. Factories that needed mechanical power would soon appear on waterfalls near big cities. Wind power moved ships across the oceans, and Americans had begun to mine coal for their iron industry.

the more we use . . . the more we want . . .

Scale 1 centimeter = 10 million Btu per person per year.



1900

Life in America had changed a lot. Trains crossed the prairies to California, steamships travelled to Europe — and coal powered them both. Coal fed the boilers of factories and heated city homes. Coal-burning tractors were even taking the place of horses on farms.

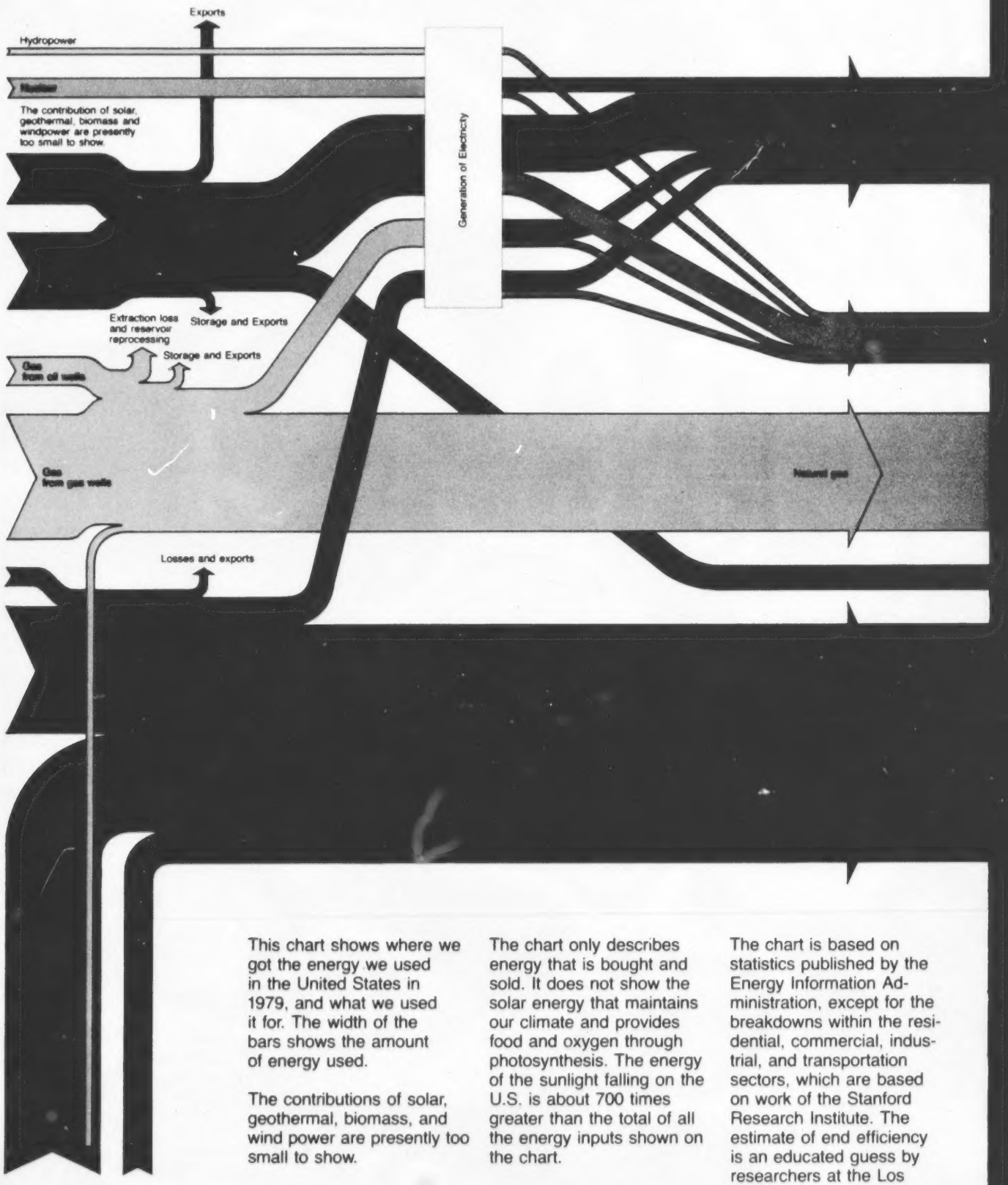
Coal was king! But there were signs of things to come. Oil and natural gas were being used for lighting (in a few large cities there were even electric lights — the electricity usually came from coal-fired generator stations). And a few thousand horseless carriages had been sold, with gasoline engines.

1979

Oil had replaced coal as the main source of energy. Transportation and manufacturing were using much more energy — but, most important, look at how much more energy each person is using today.

Sources		Uses	
Food Energy	■	Transportation	□
Firewood	■	Industry	■
Coal	■	Food	■
Hydropower	■	Homes, Offices, Stores	■
Petroleum	■	*Space Heating*	■
Natural Gas	■	*Cooking*	■
Nuclear	■	*Water Heating*	■
Other	□	*Refrigeration*	■
		Other	□

here it comes... Energy Production


Exports
Hydropower
The contribution of solar, geothermal, biomass and windpower are presently too small to show.
Generation of Electricity
Extraction loss and reservoir reprocessing
Storage and Exports
Storage and Exports
Losses and exports

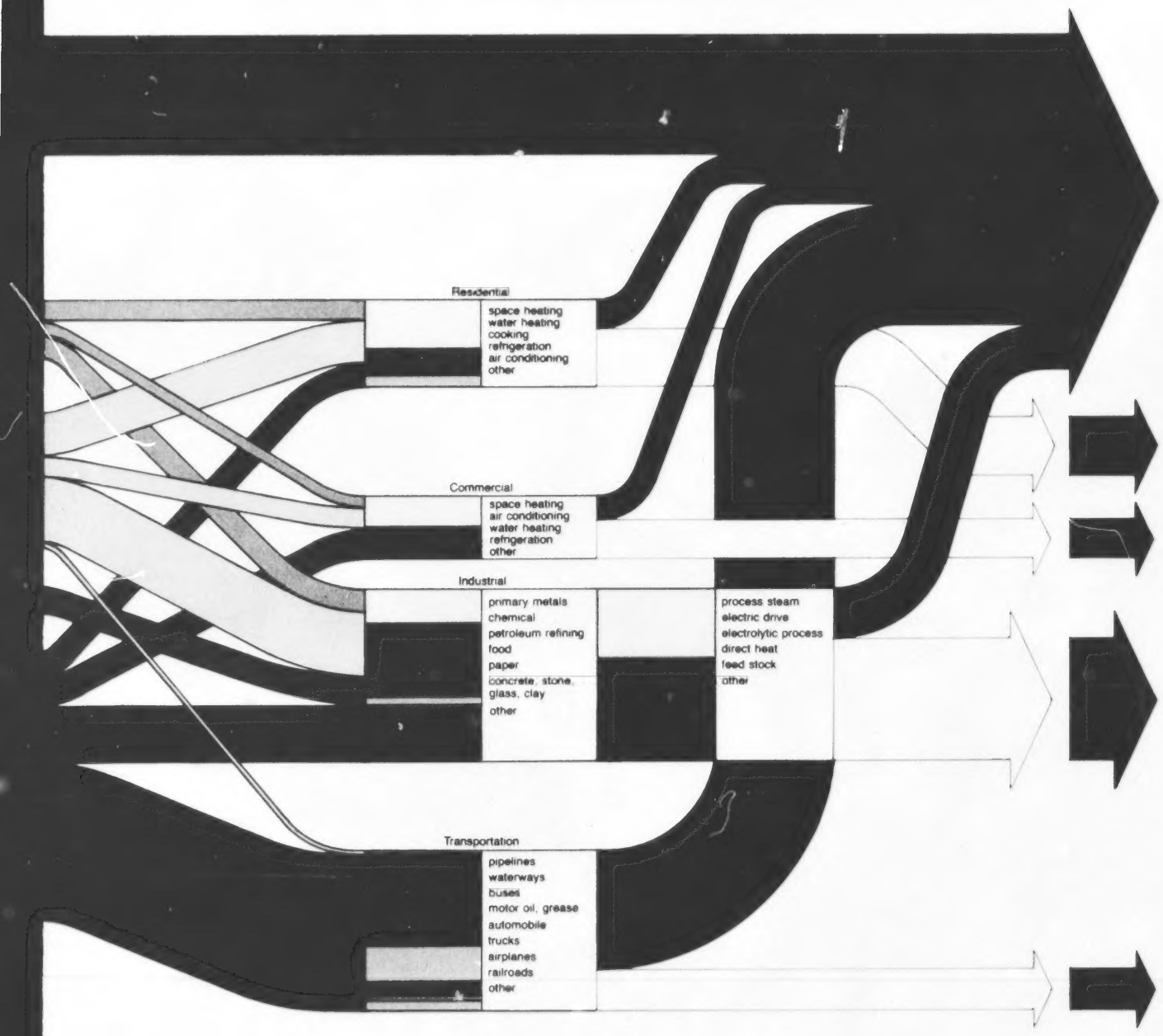
This chart shows where we got the energy we used in the United States in 1979, and what we used it for. The width of the bars shows the amount of energy used.

The contributions of solar, geothermal, biomass, and wind power are presently too small to show.

The chart only describes energy that is bought and sold. It does not show the solar energy that maintains our climate and provides food and oxygen through photosynthesis. The energy of the sunlight falling on the U.S. is about 700 times greater than the total of all the energy inputs shown on the chart.

The chart is based on statistics published by the Energy Information Administration, except for the breakdowns within the residential, commercial, industrial, and transportation sectors, which are based on work of the Stanford Research Institute. The estimate of end efficiency is an educated guess by researchers at the Los Alamos Labs.

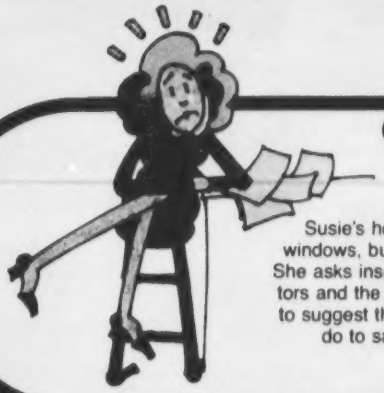
& Consumption... there it goes



Scale 1 mm = 0.7 quadrillion Btu

Investing in Energy

Susie Homeowner's energy bills are going up. What can she do about it?



1

Susie's house has storm windows, but no insulation. She asks insulation contractors and the utility company to suggest things she could do to save energy and money.

Jack, Jane & Jim Investor, who live in a small Rocky Mountain town, have saved $50,000. They would like to use their savings to make more money.

1

To do that they have to find something people need and will buy. Energy is something people in their town need. Could they sell energy?

Money Out

5

Every investment has some risks. The forest could burn down. A freak storm could destroy the windmill. The greater the risk seems to be, the greater the return needed to attract a rational investor like you.

All ways of getting energy cost something. There is only so much money with which to do things, so we have to decide what to do first. One way of deciding what to do is to choose those projects that will return the most money for each dollar spent.

If you were one of the investors, what would you choose to invest the $50,000 in?

possibility	left after 25 years
firewood	$362,668
wind generator	$528,290
bank account	$466,754

8

For the crawl space, Susie discovers that at the end of five years she would have $79 less than the $308 she'd get by leaving the $200 in the bank. Susie decides to insulate her attic, but not the crawl space. Instead, she is figuring out whether it would pay to trade in her old car for one that uses less gas.

Some ways of saving energy are free, but we often have to spend money to save energy. We get the money invested back in savings on energy bills. The smart thing is to do first the things that will save the most money per dollar invested.

year	money saved by end of year	interest earned at 9%	year-end cash
1	$153 + $113 tax credit	$0	$266
2	$168	$24	$458
3	$185	$41	$684
4	$204	$62	$950
5	$224 + $500 resale value	$86	$1760

2

things to do	price	annual saving
caulking and weatherstripping	$100 (do-it-herself)	$117
insulate attic	$750	$153
insulate crawl space	$200	$26

How much Susie saves each year depends on the price Susie has to pay for energy. She expects to keep her house five more years, and thinks the price of energy will rise 10% per year during those years. If so, an insulated attic would save Susie $224 in the fifth year, and an insulated crawl space $38.

3

It looks pretty obvious that weatherstripping and caulking would be a good thing to do. In the first year she will get back all she spent and $17 more. After that, she will save at least $117 a year until the caulking wears out.

But it isn't so clear whether Susie should spend the $750 for the attic or the $200 on the crawlspace. Susie needs to find out what her costs and savings would be during the five more years she expects to keep the house.

2

They could set up a firewood business. They could buy 100 acres of wooded land for $40,000. For $10,000 more they could get a truck and equipment to cut and haul the wood. If they cut only as much wood as grows each year, they would get 100 cords per year, which could be sold for $16,000 a year. But they would have to pay for gasoline, truck, and saw maintenance, and the wood-cutter's wages, which they estimate would total $15,000. They think the value of the land, the price of wood, and wages and other costs will go up about 7% a year. They figure out that if they did this, banking earnings at 9%, at the end of 25 years the value of the land and the profits would be $362,668.

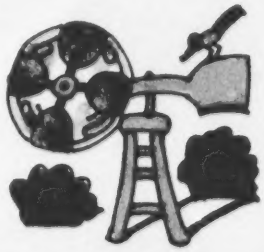
Money In

3

They could buy a wind generator for $37,800 plus $12,200 for shipping, land, and installation. At 7¢ a kWh, they could get $3500 for the electricity generated the first year, and maintenance the first year would cost $200. They think this cost and the selling price of the electricity will go up 7% a year. They can invest earnings at 9%. The machine should last for 25 years, and then the land and machine could be sold for $1000. At the end of 25 years, they would have $528,290.

4

Or they could put their money in certificates of deposit in the bank, where it would earn 9% interest. If they did this, at the end of 25 years they would have $466,754.



4

Susie has saved money that is earning 9% interest each year. If she leaves the $750 in the bank, at the end of five years she will have $1155, and $308 if she leaves the $200 the crawl space would cost. On the other hand, if she could lower her energy bills, she could save the extra money and earn interest on it.

7

Susie takes $750 out of the bank and insulates the attic. In five years she will have $1760 instead of the $1155 she would have if she left the money in the bank. She will be $605 ahead!

6

Susie will also save some taxes. Congress allows you to deduct 15% of the first $2000 you spend on insulation from your income tax. $750 × 15% = $113; $200 × 15% = $30

5

Susie calls a friend who is a real estate agent. He says he thinks that buyers five years from now might pay $500 more for her house if the attic was insulated, but they might not realize insulation in the crawl space was valuable.

(Only oil and gas traded between nations is shown. Arrow width is proportional to volume of trade, except that all flows of less than 400 thousand barrels per day are shown by thin arrows of the same width.)

Buying energy abroad

Oil is by far the biggest item in world trade, in both bulk and value. The United States buys the most. Our chief suppliers are Saudi Arabia (16% of the crude oil we buy), Nigeria (13%), and Venezuela (8%). We also buy refined products from other nations that began as crude oil from these nations.

In 1980, we bought about 80 billion dollars worth of oil from other countries. Eighty billion dollars is about the value of everything General Motors, IBM, General Electric, and U.S. Steel own all together. It is as much money as the thousand companies with the biggest incomes in the United States earned in 1978.

Cost alone does not tell the whole story. In 1978 Germany and Japan together bought about as much oil as we did. They have no oil fields in their countries. But they sold more goods to other countries than they bought. We did not succeed in doing that, and that made the dollar worth less.

Finally, it is a long way to the Middle East and Africa. If there were ever another war like World War II, it would be almost impossible to prevent the sudden loss of half our supply of liquid fuels. And, of course, our suppliers could turn off the oil, as many did in 1973.

■ Petroleum
■ Natural Gas

Saving Energy Dollars

If your family's like most, you could really lower your home energy bills. Some people have cut theirs in half! You don't have to freeze in the dark to do it, either. Most of the energy dollars spent at home are spent just to move heat around. The more control you get over the moving heat in your house, the lower your bills can be.

trees

Trees and vines can shade your southern windows in the summer; but after losing their leaves they let in the welcome winter sun. Awnings can do the same thing. If winter brings cold northern winds, plant conifers to protect the side of the house they strike.

kitchen

Are your pots the same diameter as your burners? Do they have lids? If you've an electric stove, turn the burner off a few minutes before the dish is done; it'll coast to a stop itself. If you've a kitchen exhaust fan, in the winter only use it as long as necessary; it's pushing heated air out of the house (in the summer, use it as long as the kitchen is hotter than the air outside). And if you've a gas range, when it's time to buy a new one think about one with electronic pilotless ignition.

dishwasher

If you've a *dishwasher*, run it with full loads. Try air drying your dishes by stopping the cycle at dry and opening the door.

refrigerator

Is the seal on your *refrigerator* door still good? Try slipping a playing card in. When it's time to buy a new one, remember manual defrost is more work, but lower bills. Read and use the energy labels.

furnace

If your furnace is oil-fired, when's the last time it had a tune-up? You could save 10% on your fuel bills. On a very cold day, does it run almost constantly? It should; if it doesn't, it's set wrong.

If you have forced air heat, check the filter every month. Hold it up to the light, if you can't see light through it, it's time for a new filter. (Unless you've a permanent filter.)

Do the ducts from your furnace run through an unheated area? Then they probably need to be insulated.

hot water

Heat is escaping from the walls of your gas or oil-fired water heater. Feel it! Adding extra insulation reduces fuel costs as much as 15%. If you don't have an old-fashioned dishwasher that needs 140° water, you can save by turning the water heater thermostat down, say a little below the normal mark. The sediment that accumulates in the bottom of a water heater is an insulator that keeps heat out of the water. Get rid of it by draining a few bucketfuls from the tap on the side of the heater every few months.

... at home

attic

In most parts of the country, it pays to insulate your attic, often about 8% of the heating bill. When the outside temperature is 82° or less, you can also cool your house with a *whole-house fan* that pushes warm air out of the attic.

thermostat

You can save about 3% on your fuel costs for every degree Fahrenheit you lower the thermostat in winter, and about 1% for every degree you dial down at night. Forgetful? A clock thermostat will remember to do it for you—and if the whole family's away during the day, why heat the house? Just tell the clock thermostat to warm it up before you get home.

faucet

A leaky faucet! Hot, too. You're paying for the heat *and* the water.

If your hot water pipes run through unheated parts of the house, it may pay to insulate them.

washer & dryer

With today's detergents, warm or cold water will do just as good a job as hot on most kinds of laundry. Try it. Use full loads unless your washer has special settings for small loads.

fireplace

Some of the heat rushing up the chimney is not from the fire but from your furnace. If you're using an open fireplace, close all doors and air ducts to the room. Open the window nearest the fireplace a half inch or so. And remember to close the damper when the fire's out.

walls

In very cold climates (or very hot climates where air conditioning is used), it can pay to insulate the walls of your house. It's expensive; but you could save 16 to 20% a year on utility bills.

windows

Windows are the weakest part of your home's barrier against the outside world. Glass is a poor insulator; using two panes (three in very cold climates) or storm windows can lower your heating bills as much as 15%. Increase the insulation by drawing heavy drapes on cold winter nights.

Windows are also a likely place to find holes where the wind can push cold air in, pull the heated air out of your house. You may even be able to feel it! Weatherstripping the window and caulking around its frame will stop that.

door

Can you slip a quarter under your door? Then the wind can get through too. Weatherstripping is needed, and in a very cold climate, a storm door.

whole house

Heating rooms you're not using? You don't have to heat the whole house. Dad's workshop might be more comfortable if it were cooler; and Grandma needs her room a little warmer. Lights are the same way. Certain jobs need bright light, but that doesn't mean the whole room has to be bright. Consider fluorescents, and remember that one big light is more efficient than two small ones.

Conservation: Energy & happiness

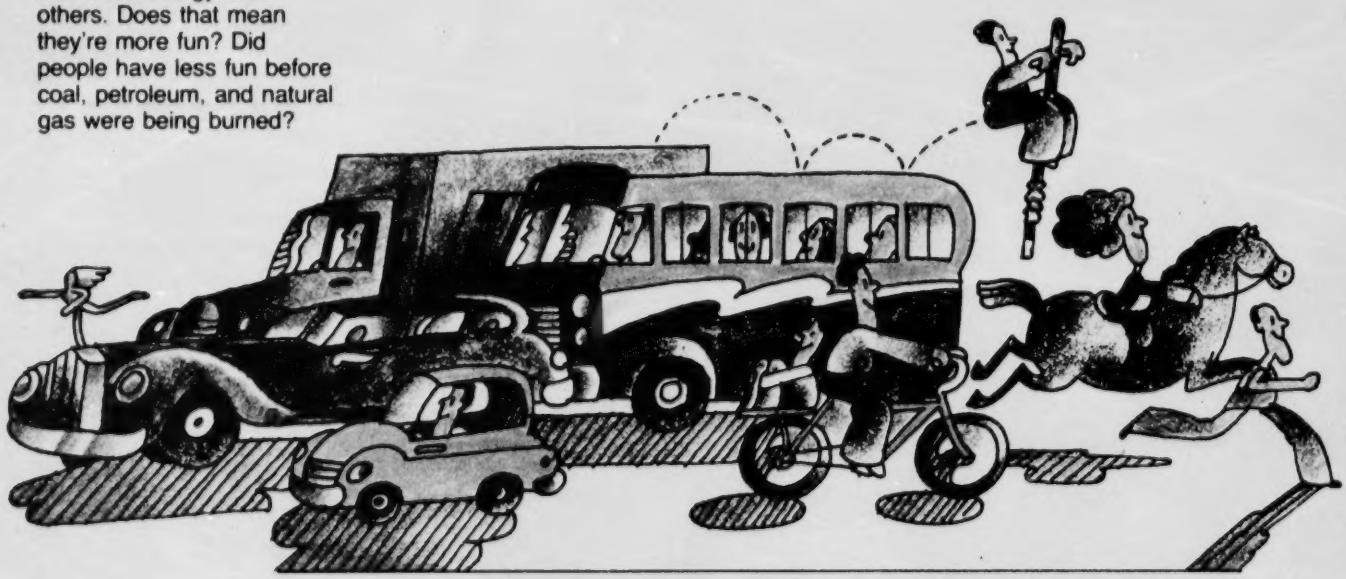
Some people seem to believe that to have a better life, you have to use more energy. You need a bigger car, more meat on the table, air conditioning, power roller skates, a motor boat, and so forth. Then life would really be fun. Is this true? Or is it possible to use less energy and also enjoy life more?

A quarter of all the energy used in the United States is used directly for transportation. People neded to go from place to place. Different ways of going use different amounts of energy. In a city, it takes a bus about 3,800 Btu's of energy to carry a person one mile. It takes a car 8,100. Suppose the bus system does use less energy than the private car system. Will your life be less fun if you go by bus instead of by car?

A private car can be as clean and comfortable as we can afford. It saves our time by leaving when we are ready and going exactly where we want. It protects us from the weather and takes us long distances fairly quickly.

On the other hand, buying and using a car costs money that might have bought other satisfactions. Parking hassle is a cost, and there are costs paid by the community, like the cost of space for roads, parking lots, and service stations, and costs of air pollution damage. Everybody needs to think carefully about *all* the costs and benefits of the forms of transportation they choose. You might not choose to ride a bicycle just because it's energy-efficient, but you might if it also keeps you healthier.

Some ways of having fun use more energy than others. Does that mean they're more fun? Did people have less fun before coal, petroleum, and natural gas were being burned?



A lot of energy goes for making and moving things that soon end up as rubbish. Then we use more energy hauling the rubbish away. An appliance that can be easily repaired and lasts a long time saves the energy that would be needed to make and deliver a new one. On the other hand, a new appliance may be so much more energy-efficent than the old model that the energy needed to make and run it for a few years is less than the energy that would hav been needed to repair and run the old one. In a situation like this, figuring your costs is often a good way of deciding what will save the most energy.

But not always. Take paper bags. Supermarkets give them away "free" by charging every shopper a little bit extra on everything they buy, to pay for the bags. In Europe, where bags aren't free, many shoppers bring their own and energy is saved.

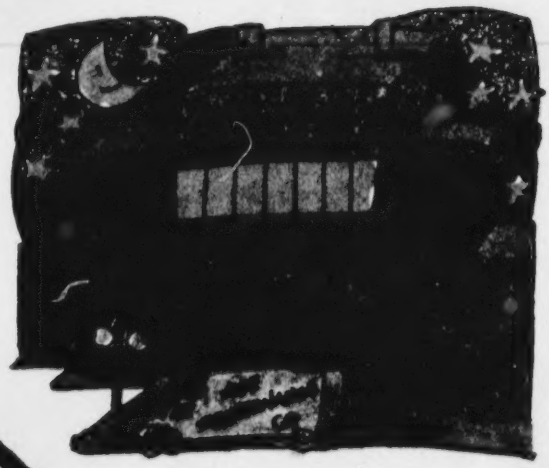
In the past, we made certain choices partly because energy was cheaper than it is now, compared to other things. When gasoline was cheaper, many people who worked downtown decided to commute from the suburbs. It takes more energy per person to support a suburb dweller than a person living in a city apartment. Now young couples are moving back into some cities. They've found that for the same money they can have a better life living downtown.

People who move from the wet Eastern parts of our country to the dry Southwest sometimes want to live in Cape Cod houses with green lawns. But it takes extra energy to do that. Their grown-up children may rediscover the energy-saving architectural principles Indians and early Spanish settlers worked out. Do you think people who adapt their lifestyle to their climate are any less happy than those who don't?

Energy saving at work

Businesses and industries need energy to provide the goods and services we buy. Rising energy costs are making business people look for ways they can produce more using less energy. Since the 1973 Oil Embargo, business in general seems to have done a better job of saving energy than households have done.

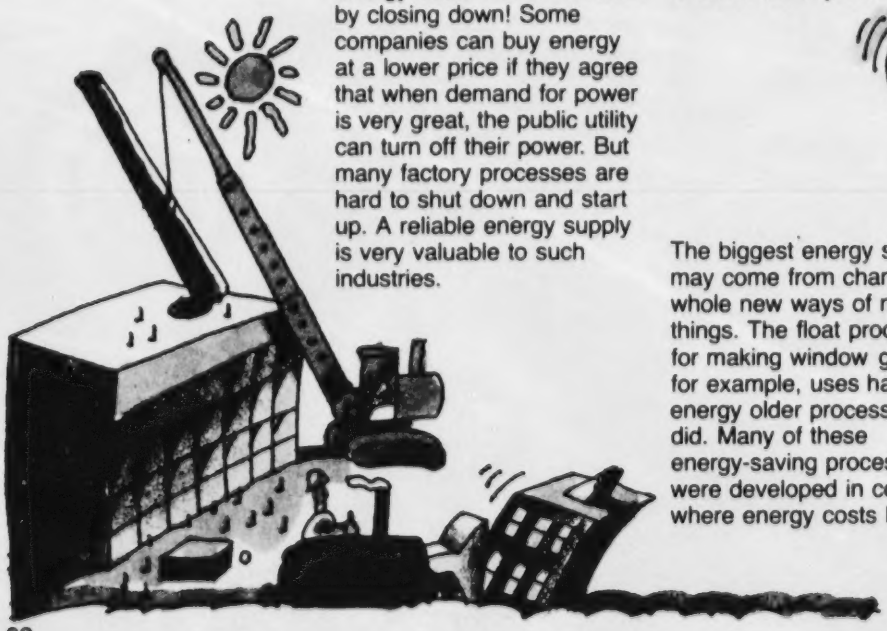
One way businesses save energy is by practicing thrifty habits. One office building asked all night cleaning crews to work on the same floor at the same time, leaving other floors dark. Hundreds of dollars worth of electricity were saved each month.



Industries can seek substitutes for energy. Sometimes more labor can be used instead of energy. Using new materials can save energy. A vacuum cleaner maker changed from die-cast metal to plastic. It took oil, gas, and energy to make the plastic and mold it. (The color and all the screw holes were molded in.) But it took almost three times as much energy to smelt the metal, cast it, drill the screw holes, buff it, make the paint, and paint it.

Businesses also save energy by finding ways to use heat that used to go up the chimney. Spark plugs are fired in a furnace at 1800°F, then allowed to cool. A spark plug maker installed a duct to use hot air from the cooling spark plugs to heat the building. The change cost $9,920. $25,546 worth of fuel is saved each year.

Energy costs can be reduced by closing down! Some companies can buy energy at a lower price if they agree that when demand for power is very great, the public utility can turn off their power. But many factory processes are hard to shut down and start up. A reliable energy supply is very valuable to such industries.



The biggest energy savings may come from changing to whole new ways of making things. The float process for making window glass, for example, uses half the energy older processes did. Many of these energy-saving processes were developed in countries where energy costs have been higher than ours for years. Now America is catching up.

Building whole new factories takes a lot of money and effort. But improving the energy-efficiency of American businesses will reduce costs and our need to import oil, and provide jobs in healthy, competitive industries.

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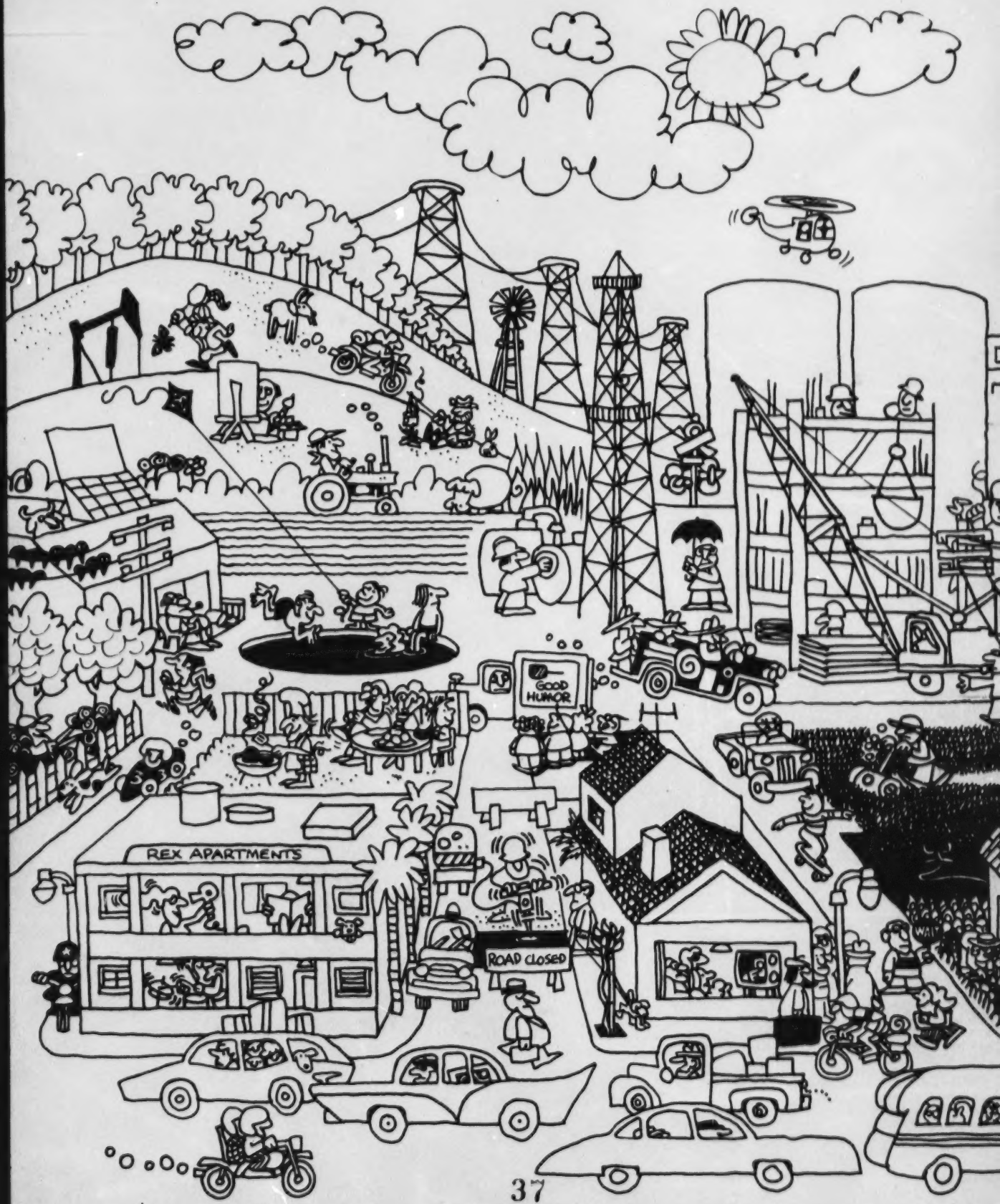
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